



Retreatment of Calcium Silicate Based Root Canal Sealer – A Literature Review

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Abstract

Calcium silicate-based root canal sealers have gained increasing attention in endodontics due to their bioactive properties, biocompatibility, and ability to form a chemical bond with dentin. While their clinical performance in primary root canal therapy has been widely reported, limited literature addresses the challenges associated with their removal during retreatment procedures. These sealers, owing to their chemical stability, high bond strength, and penetration into dentinal tubules, may complicate re-access and complete canal debridement. This literature review examines the current evidence on the retreatability of calcium silicate-based sealers, with emphasis on the efficacy of various removal techniques including rotary and hand instrumentation, adjunctive use of ultrasonic and laser systems, and solvent-assisted methods.

Keywords: Retreatment; Calcium Silicate; Root Canal Sealer

Introduction

Primary root canal therapy is generally a reliable procedure, with success rates of at least 82% to 92.6% [1]. Treatment failure can result from incomplete chemo-mechanical debridement, leaving contaminated pulpal tissue behind, as well as recurrent caries, tooth fractures, or inadequate coronal restorations, which foster bacterial biofilm formation and compromise the tooth's survival [2]. When the endodontic lesion persists, various treatment options are available such as: retreatment, surgical intervention or even the extraction of the offending tooth. However, non-surgical endodontic retreatment is considered as the first option to be opted for, whenever feasible, as it fosters periradicular healing while preserving the tooth structure, with a reported success rate of 77% [3].

The primary goal in non-surgical retreatment is to regain the access to the canal and the apical third of the canal by complete removal of the obturating material, as a residual filling material act as a mechanical barrier, hindering effective disinfection of the canal including complex areas of the canal.

Calcium silicate – Based sealers (CSS) have been introduced into endodontics due to its excellent biocompatibility, bioactivity as well as good sealing ability [4]. These materials are categorised as hydraulic materials since they undergo setting by hydration reaction, producing calcium hydroxide and calcium silicate hydrate gel (CSH gel), which interacts with the calcium and phosphate-based fluids to produce the hydroxyapatite [5].

Challenges with retreatment of CSS obturated canals

In spite of their tremendous clinical popularity, one of the major limitations to their use is difficulty in retrieving these sealers, as no clinically established solvents are currently available to dissolve these sealers, unlike the traditional sealers where solvents such as chloroform can be used. Due to their hydration-based setting reaction, they micromechanically bond to dentin, increasing dislocation resistance and reducing gaps at the interface, makes the removal more difficult [4].

The challenges associated with the retrievability of CSSs might also depend on the final setting of the sealers. Soft-setting CSSs are easier to remove from the root canal system, whereas hard-setting CSSs might necessitate the use of solvents in combination with mechanical debridement [6].

The physical strength of the set CSS is a critical factor that determines its retrievability, with different brands of material exhibiting different degree of retrievability, attributed to their difference in physical properties. Soft set sealers are considered to be easier to retrieve when compared to hard set ones [7].

Another important factor determining the level of difficulty in retreatment is amount of sealer used in relation to the GP and regaining the patency of the canal. When the gutta-percha fails to reach the full working length the presence of CSSs beyond its apex or presence of CSS in intricate areas of the canal (such as isthmus or lateral canals), can pose a significant challenge during retreatment.

Thus, various techniques have been tried in order to achieve higher efficacy in the removal of CSS, though none succeeded in full retrieval.

Current techniques for retrieval of calcium silicate-based sealers from the canal

Current CSSs retrieval techniques can be divided into chemical and mechanical techniques.

Solvents for dissolution of calcium silicate-based sealer

Numerous studies have assessed various chemical agents that can be used for retrieving CSSs. Studies evaluated solutions such as EDTA, NaOCl, carbonated water and several acids, but reported that these solution could neither dislodge or dissolve the CSS sealer successfully [8]. Carrillo CA, *et al.* when compared between 6% sodium hypochlorite, 5% acetic acid and carbonated water, reported that using solutions generally decreased the retrievability of all three sealers compared to no solution, and the tested sealers were consistently retrievable from straight canals even without any solutions [7].

A study by Drukteinis S *et al* assessed the interplay and dissolving capability of 10% and 20% citric acid, compared to 17% EDTA, reporting that 10% and 20% both caused higher dissolving characteristics than EDTA, with evident surface structural changes seen as pores and cracks on the sealer surface, with no significant impact on the microstructure of root dentin [9]. Rezaei G *et al* compared the efficacy of 10% formic acid, 20% hydrochloric acid and chloroform in retreatment of canals obturated with CSS, reported that though 20% HCl showed superior efficacy than 10% formic acid and chloroform, clinically no significant differences were noted and its use is limited due to its highly corrosive nature [10].

Mechanical methods

Numerous studies have evaluated the effectiveness of conventional hand files, as well as modern rotary and NiTi files, in the removal of CSSs. A study conducted by Donnermeyer *et al* comparing between H files, Reciproc R40, Mtwo retreatment files and F6 Sky-Taper size 040, reported that all the NiTi files performed better in comparison to the H files used. However, among all the NiTi files, F6 SkyTaper files were found to be fastest in removing the CSS [11].

Files such as M wire Reciproc and Reciproc Blue have been also advocated aifing to their ability in preserving the root canal's anatomy especially in curved canals, with no statistically significant differences between them. [12].

Enlarging the canals 2 -3 sizes larger than the initial preparation size, reduces the amount of residual sealers but at the expense of compromising the root dentin strength. Rotary systems such as Protaper Universal or D Race system have been tried alone or in combination with other tools such as XP- Endo finisher, thus improving the removal efficiency of the rotary files [13].

Ultrasonics play a very significant role in the removal of calcium silicate sealers during endodontic retreatment by enhancing the disruption of the set sealer material from the canal walls. Combining ultrasonics with instrumentation has been studied and found to be significantly better at removal of residual sealers from the canal walls. Colombo JA et al compared the ability of reciprocation instrumentation followed by continuous ultrasonic irrigation (CUI) in their ability of removing calcium silicate sealers from oval shaped mandibular premolars using micro CT, and found that this combination approach improvised the sealer removal, by agitating the irrigant for better penetration and cleaning and also dislodgement of the sealer from the walls. [14].

Passive Ultrasonic irrigation (PUI) is also shown to be effective compared to rotary systems in the retrieval of calcium silicate sealers from the root canal walls, improving the cleanliness with minimal loss of radicular dentin [15].

It is also hypothesized that using ultrasonic instruments activation directly over the set sealer can be effective in disrupting the material, however it is possible only when the sealer is within the visibility limit.

XP Endo Finisher and XP Endo Finisher R are supplementary rotary instruments used at 800rpm with gentle vertical and brushing motions in conjugation with ultrasonics to enhance the removal of CSS with minimal removal of radicular dentin. Studies claim that XP-FR achieves about 30to40% greater removal of sealers from the canals, outperforming the isolated use of PUI especially in curved or oval shaped canals. This is attributed to the specialised design of XP Endo systems [16]. However complete removal is yet not possible with these systems.

EDDY sonic irrigation, which are made of flexible polyamides and operated at high sonic frequencies (~6,000 Hz), produces a three-dimensionally oscillating motion that generates cavitation and acoustic streaming, thus enhancing the irrigant activation and cleaning efficiency. It has also been evaluated for its role in enhancing the removal of CSS during retreatment, especially from the apical third. It is reported that EDDY removes significantly greater CSS in the apical region compared to conventional needle-based irrigation, PUI and XP- Endo Finisher, thus making it an excellent aid in the removal of CSS in challenging areas of the canal [17].

Lasers such as Er:YAG and Er,Cr:YSGG have also been studied in removal of CSS, however efficiency stays limited. A recent systematic review comparing the effect of laser on bond strength of resin-based sealers and CSS, reported that laser is not efficient enough to be used alone for removal of CSS compared to conventional methods like EDTA irrigation or other solvents [18]. However, combining them with other adjunctive methods such as XP-Endo finisher or reciprocating instruments may facilitate but does not aid in complete removal.

The efficacy of shock wave-enhanced emission photoacoustic streaming (SWEEPS) in CSS removal has also been examined in several studies. Angerame et al compared between SWEEPS and PUI, and concluded that combination of reciprocating instrumentation with SWEEPS provided more satisfying results than the usage of reciprocating instrumentation combined with PUI [19].

Modern irrigation techniques such as GentleWave and EndoVac have also been studied for the removal of CSS. GentleWave has demonstrated superior ability to remove calcifications as well as smear layer efficiently even from inaccessible areas to traditional instruments, thus suggesting its potential advantage in retreatment cases where CSSs are deeply integrated with dentin or located in complex canal spaces. Micro-CT studies reported that GentleWave outperformed other methods in the removal of filling remnants, although no technique, including GentleWave, achieved complete removal of CSSs from the root canal system [21].

EndoVac system, a negative pressure irrigation device designed for enhanced irrigation particularly in apical third area, has been studied in the context of CSS removal. A study comparing between GentleWave and Endovac reported that GentleWave removed the highest ratio of the residuals of the root canal filling material, followed by the side-vented needle, whereas Endovac was least effective for the purpose [20].

Combination of mechanical and chemical methods

A study by M Garrib evaluated the efficacy of removal of CSS using 17% EDTA and 10% and 20% formic acid in conjunction with mechanical instrumentation, and reported that using 10% formic acid alongside mechanical instrumentation proved highly efficient in eliminating obturation material, achieving over 95% removal and facilitating the reestablishment of patency and working length [8].

A recent systematic review by Al Akam et al reports that no single chemical agent or mechanical aid is successful in complete removal of CSS, thus combination of these can enhance the removal. The review also concluded that the combination of 10% formic acid or 17% EDTA irrigation with mechanical instrumentation is the currently the most effective strategy for CSS retrieval [21].

Experimental studies also report that after initial mechanical retrieval with rotary or reciprocating files, supplementary use of advanced aids such as XP endo finisher and chemical agents can further reduce the volume of residual CSSs, thereby supporting the beneficial role of combining the different approaches [22].

Role of extruded Calcium silicate sealer

The removal of bioceramic sealers, particularly when extruded beyond the apex, is a recognized clinical challenge. Most cases with extruded CSBS heal without need of any intervention, and the extruded material generally does not impact on healing nor cause any persistent symptoms due to its biocompatibility. In some scenario, the extruded material may even promote healing due to the osteoinductive nature of the material [23]. However, extrusion should still be avoided due to other potential risks such as extrusion into anatomical structure etc.

However, most literature available focuses mainly on the re-treatability of CSBS within the canal, specific references regarding the removal of CSBS which is extruded beyond the apex is limited. Mechanical methods such as NiTi rotary files, reciprocating systems and use of supplementary files such as XP Endo Finisher are the primary conservative approaches for removing CSBS. However, these methods can efficiently remove much of the root-filling material, but complete removal—especially of extruded material beyond the apex—is rarely achieved [24]. Ultrasonic instruments can help break up accessible sealer, especially when activated directly on the set material, but their use is limited to straight canal portions and visible material, and their role in extruded material remains questionable [25].

Studies report that body may phagocytose or encapsulate the extruded material, and adverse outcomes are rare [26]. However, in cases where extruded sealer causes persistent symptoms or complications (e.g., pain, swelling, paresthesia), surgical intervention may be considered [27].

Clinical implications and future directions

Despite the challenges associated with the removal of calcium silicate sealers, clinical studies have reported similar success rates for root canal retreatments using CSS and epoxy resin sealers [28]. The ability to regain apical patency and working length is variable and may depend on the obturation technique and the specific CSS used, i.e; greater the amount of CSS used, greater will be the difficulty in retreatment of such cases [7]. There is a clear need for research into new solvents or chemical agents specifically designed to soften or dissolve set calcium silicate-based sealers without damaging dentin or surrounding tissues.

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