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Evaluation of efficacy of dissolving effect of RC Solve, Eucalyptus Oil and Carvene on Premixed Bioceramic Sealer: An Invitro Study

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KEYWORDS

Bioceramic sealer, CeraSeal, solvent efficacy, RC Solve, Carvene,

ABSTRACT:

Background: The complete removal of root canal obturating materials is a critical step in nonsurgical endodontic retreatment to facilitate adequate disinfection and promote periapical healing. Bioceramic sealers, owing to their chemical adhesion to dentinal walls and dimensional stability after setting, present a significant challenge during retreatment procedures. The use of organic solvents has been advocated to soften obturation materials and reduce the risk of procedural errors associated with purely mechanical removal. However, there is limited evidence regarding the effectiveness of essential oil–based solvents in dissolving premixed bioceramic sealers.

Aim: This in vitro study aimed to evaluate and compare the dissolving efficacy of RC Solve, eucalyptus oil, and Carvene on a premixed bioceramic root canal sealer (CeraSeal).

Materials and Methods: Thirty standardized stainless-steel ring molds (8 mm diameter × 2 mm height) were filled with premixed bioceramic sealer (CeraSeal) and incubated at 37°C for 48 hours to ensure complete setting. The initial weight (w_1) of each specimen was recorded using a digital analytical balance. The samples were randomly allocated into three groups (n = 10) based on the solvent used: Group I – RC Solve, Group II – Eucalyptus oil, and Group III – Carvene. Each specimen was immersed in 10 mL of the respective solvent for 10 minutes, rinsed with distilled water, dried, and re-incubated at 37°C for 24 hours. The final weight (w_2) was recorded, and the dissolving effect was calculated as the difference between initial and final weights ($w_1 - w_2$). Intergroup comparison was performed using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test at a significance level of $p < 0.05$.

Results: All tested solvents demonstrated the ability to dissolve the bioceramic sealer to varying extents. The highest mean weight loss was observed in the Carvene group (0.0102740 ± 0.00341757), followed by RC Solve (0.0070500 ± 0.00197115), while eucalyptus oil exhibited the least dissolving effect (0.0046690 ± 0.00051015). Intergroup comparison revealed a statistically highly significant difference among the three groups ($p < 0.001$). Pairwise analysis demonstrated highly significant differences between eucalyptus oil and Carvene, and between eucalyptus oil and RC Solve ($p < 0.001$), whereas a statistically significant difference was noted between Carvene and RC Solve ($p < 0.05$).

Conclusion: Within the limitations of this in vitro study, Carvene demonstrated superior dissolving efficacy on premixed bioceramic sealer compared with RC Solve and eucalyptus oil. Essential oil–based solvents may serve as safer alternatives for facilitating the removal of bioceramic sealers during retreatment procedures. Further studies are required to evaluate their effectiveness under clinical conditions and in conjunction with adjunctive techniques such as ultrasonics.

INTRODUCTION

The principal objective of nonsurgical endodontic retreatment is to facilitate healing of periapical tissues that have been compromised by reinfection. Such reinfection commonly occurs as a consequence of apical or coronal microleakage, or due to deficiencies in the previous root canal therapy.[1] Achieving a hermetic three-dimensional obturation that adequately fills the complexities and anatomical variations of the root canal system is therefore considered fundamental[2] in preventing the persistence of microorganisms within the canal space or surrounding periapical region.[3] In instances where primary endodontic treatment is unsuccessful, a conservative nonsurgical retreatment approach is generally recommended before considering more invasive treatment options.[4] As part of the retreatment procedure, chemical solvents are frequently employed to soften gutta-percha, thereby facilitating the removal of the existing obturating material. However, effective elimination of the root canal sealer is equally critical, as residual sealer may harbor debris and

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microbial contaminants that contribute significantly to treatment failure.[5]

Endodontic solvents are routinely employed to reduce the bonding strength and mechanical resistance of obturation materials within the root canal system, thereby aiding their removal during instrumentation procedures.[6] These agents have traditionally been utilized for the dissolution of gutta-percha and are regarded as some of the most effective chemical substances for disintegrating root canal filling materials.[7]

A variety of chemical solvents are utilized during endodontic retreatment procedures. Evidence from previous studies suggests that chloroform demonstrates greater efficacy in dissolving obturation materials when compared with other agents such as eucalyptol, halothane, and xylene. Nevertheless, its clinical use has been restricted by the U.S. Food and Drug Administration owing to concerns related to its potential carcinogenic effects.[8] While xylene has not been identified as a carcinogenic substance, it is known to exhibit significant cytotoxicity toward surrounding tissues. In view of these limitations, the present study incorporates three organic solvents that are regarded as relatively biocompatible and safe for periapical tissues.

RC Solve is an orange oil–based solvent developed for the dissolution of gutta-percha as well as root canal sealers.[9] Eucalyptus oil, obtained from the leaves of *Eucalyptus globulus*, a member of the Myrtaceae family native to Australia and currently cultivated worldwide, has also been used for similar purposes in endodontic procedures.[10] Carvene, which is formulated using D-limonene as its primary component, is intended to facilitate the removal of gutta-percha and sealer materials from the root canal system. However, there is currently a lack of published evidence assessing the solvent efficacy of Carvene.

Bioceramic endodontic sealers (BCS) have been in clinical use for approximately the past decade. Their development can be traced back to the introduction of mineral trioxide aggregate (MTA) by Torabinejad in 1993, an innovation that significantly transformed endodontic practice. Owing to its remarkable biocompatibility and favorable physical properties, MTA allowed for the retention of teeth that might otherwise have been deemed non-restorable. Bioceramic sealers, formulated on tricalcium silicate–based technology, were subsequently developed to incorporate many of the advantageous characteristics associated with MTA. These materials exhibit superior biocompatibility, alkaline pH, effective sealing capability, and dimensional stability following setting. They are intended to be used in conjunction with a core obturation material rather than as a standalone filling substance. Despite their advantages, one notable limitation is their strong adhesion to dentinal walls, which can complicate their removal during retreatment procedures. This difficulty has led some clinicians to exercise caution when selecting these materials. Earlier investigations, including the work of Wilcox and colleagues in 1987, reported that the majority of residual material observed during retreatment consisted of sealer remnants, emphasizing the importance of thorough removal to minimize periapical irritation and inflammation.[11]

The present study utilizes organic solvents to improve the cleaning and disinfection of the root canal system, with particular emphasis on facilitating the removal of sealer remnants from canal walls and apical complexities. The main aim of this investigation is to assess and compare the dissolving effectiveness of RC Solve (Prime Dental, India), Eucalyptus oil (Ashwin Chemicals and Pharmaceuticals), and Carvene (Prevest DenPro Limited, India) on CeraSeal bioceramic root canal sealer (Meta Biomed Co., Cheongju, Korea).

MATERIALS AND METHODS

In the present study, CeraSeal, a bioceramic root canal sealer (Meta Biomed Co., Cheongju, Korea), was selected for evaluation. Stainless steel rings with standardized dimensions of 8 mm in diameter and 2 mm in height were used as molds. Each ring was placed over a microscopic glass slide, following which the sealer was mixed in accordance with the manufacturer's instructions and introduced into the molds. A second glass slide was gently applied over the top surface of each ring to obtain a smooth and uniform finish. Subsequently, the specimens were systematically numbered from Ring 1 to Ring 30.

Ten minutes following the preparation of the sealer, the specimens were placed in an incubator (Cultura, Ivoclar Vivadent) maintained at 37°C and stored for a duration of 48 hours to ensure complete setting of the material. Upon completion of the incubation period, the glass slides were gently detached, and any surplus sealer

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surrounding the stainless steel rings was carefully removed using a sharp Lecron carver.

The initial mass (w_1) of each specimen was measured in grams up to four decimal places using a digital weighing balance. To improve measurement reliability, each specimen was weighed on three separate occasions, and the mean of these readings was calculated.

Thirty stainless steel rings containing CeraSeal sealer were fabricated and subsequently allocated equally into three experimental groups.

Group I, each specimen was submerged in 10 ml of RC Solve (Prime Dental, India) for a duration of 10 minutes. An identical protocol was carried out for Group II with Eucalyptus oil (Ashwin Chemicals and Pharmaceuticals) and for Group III using Carvene (Prevest DenPro Limited, India). All specimens were immersed individually in separate glass vials during the procedure.

At the end of the 10-minute immersion period, the specimens were retrieved from the glass vials using tweezers. Each sample was subsequently rinsed with 100 mL of distilled water and gently dried with absorbent paper to remove surface moisture. The specimens were then returned to the incubator and maintained at 37°C for 24 hours to allow complete drying.

After the drying phase, the final mass (w_2) of each specimen was recorded using the same digital weighing balance. To ensure consistency, three consecutive measurements were obtained for each sample, and their mean value was calculated.

The quantity of sealer dissolved was determined by computing the difference between the initial and final weights ($w_1 - w_2$).

All observations were systematically entered into a Microsoft Excel spreadsheet (Version 2016) that was designed and verified for the purposes of this investigation. Statistical evaluation was carried out using the Statistical Package for the Social Sciences (SPSS) software (IBM Corp., Version 26.0). Both descriptive and inferential statistical analyses were conducted for the variables assessed.

To compare the dissolving efficacy of the three organic solvents on the premixed bioceramic sealer, intergroup analysis was performed using one-way analysis of variance (ANOVA), followed by Tukey's post hoc test for multiple comparisons. Statistical significance was determined at a 95% confidence level, with a p-value of less than 0.05 considered statistically significant.

Figure 1- Complete Workflow

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RESULTS

TABLES and GRAPH

Table 1 - Descriptive statistics of dissolving effect (sealer weight loss) of three different organic solvents on premixed bioceramic sealer

Dissolving effect					
Groups	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Eucalyptus Oil	10	.00392	.00538	.0046690	.00051015
Carvene	10	.00614	.01719	.0102740	.00341757
RC solve	10	.00452	.00995	.0070500	.00197115

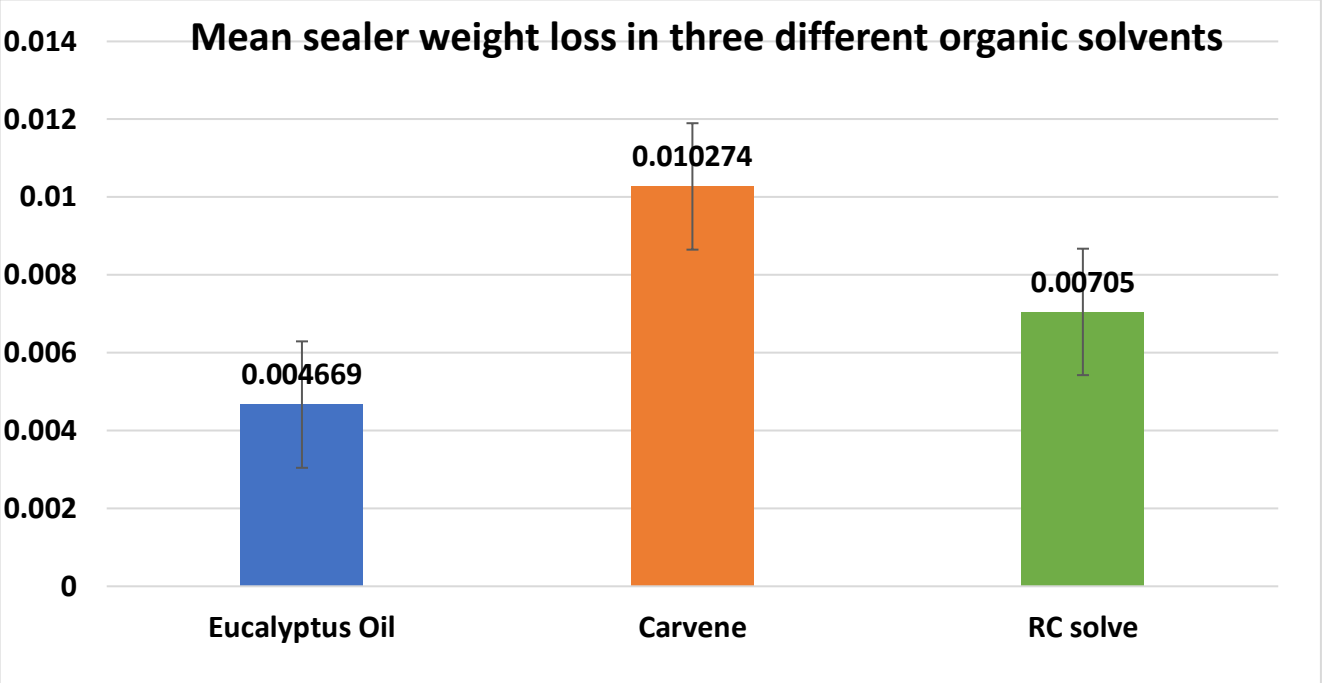

Table 2 – Intergroup comparison of dissolving effect (sealer weight loss) of three different organic solvents on premixed bioceramic sealer

ANOVA						
Parameter	**Comparison groups**	**Sum of Squares**	**df**	**Mean Square**	**F**	**p value**

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Difference in wright loss/ Dissolving effect	Eucalyptus Oil vs Carvene vs RC solve	0.000158	2	0.000079	15.001	.000*

*p value <0.05 statistically significant, <0.01 highly significant, <0.001 very highly significant

Interpretation – Intergroup comparison of dissolving effect of three different organic solvents on premixed bioceramic sealer was performed using One-way Analysis of variance (ANOVA). This comparison showed statistically very high significant differences (p value <0.001) between the 3 groups.

Table 3 – Pairwise multiple comparison of dissolving effect (sealer weight loss) of three different organic solvents on premixed bioceramic sealer

(I) Groups	(J) Groups	Mean Difference (I-J)	p value	95% Confidence Interval	
				Lower Bound	Upper Bound
Eucalyptus Oil	**Carvene**	-.00560500*	0.000026*	-.0081517	-.0030583
	RC solve	-.00238100	.050*	-.0049277	.0001657
Carvene	**Eucalyptus Oil**	.00560500*	0.000026*	.0030583	.0081517
	RC solve	.00322400*	.011*	.0006773	.0057707
RC solve	**Eucalyptus Oil**	.00238100	.050*	-.0001657	.0049277
	Carvene	-.00322400*	.011*	-.0057707	-.0006773

*p value <0.05 statistically significant, <0.01 highly significant, <0.001 very highly significant

Interpretation – Pairwise multiple comparison of dissolving effect of three different organic solvents on premixed bioceramic sealer was performed using Tukey's post hoc test. This comparison showed statistically very high significant differences (p value <0.001) between Eucalyptus oil and carvene and Eucalyptus oil and RC solve; whereas only significant differences were noted between Carvene and RC solve (p value <0.05)

DISCUSSION

The outcome of root canal therapy largely depends on the establishment of an effective coronal and apical seal, which is achieved with the aid of endodontic sealers.[12] The widely accepted technique for obturation of prepared root canals involves the use of a solid or semi-solid core material, such as gutta-percha, in combination with an endodontic sealer. The sealer plays a critical role in preventing bacterial penetration from the oral environment, entombing any residual microorganisms, and ensuring a hermetic seal at the microscopic level. This helps to inhibit the accumulation of stagnant fluids within the canal space that may otherwise act as a potential nutrient source for bacterial proliferation.[13]

Bioceramic endodontic sealers are described as non-sterile materials intended for professional application as root canal sealers, with a setting mechanism that relies on hydrophilic inorganic components interacting with water. These sealers are available either as a powder that requires mixing with water prior to use or as a premixed paste supplied in syringe form, which sets upon contact with the moisture present within dentinal tubules. Syringe-delivered formulations are preloaded and ready for direct clinical application, eliminating the need for manual mixing. A certain level of moisture within the

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root canal environment is essential for initiating their setting reaction. As reported by the manufacturer, these materials typically achieve complete setting within approximately four hours under optimal moisture conditions within the canal system.[14]

During nonsurgical endodontic retreatment, the exclusive use of mechanical techniques for the removal of obturating materials may increase the risk of procedural complications such as root perforation, canal transportation, or alteration of the original canal anatomy. The application of chemical solvents helps to reduce the hardness and adhesion of obturation materials within the canal, thereby facilitating their removal in conjunction with instrumentation.[7] Various solvents have been employed for this purpose, including chloroform, xylene, halothane, eucalyptol oil, orangewood oil, turpentine oil, and pine needle oil.[15]

Although chloroform has been widely regarded as one of the most efficient gutta-percha solvents, it has been classified as a Group 2B carcinogen by the International Agency for Research on Cancer (1987), prompting the search for safer alternatives.[16] Xylene, a chlorinated hydrocarbon commonly used for dissolving gutta-percha, has been associated with several adverse effects, including irritation of mucous membranes and eyes, gastrointestinal disturbances, chemical pneumonitis, toxic hepatitis upon ingestion, cytotoxic effects when extruded into periapical tissues, and hemorrhagic changes in pulmonary air spaces following inhalation. Consequently, there has been a growing interest in the use of essential oil–based solvents in endodontics due to their improved safety profile, biocompatibility, and non-carcinogenic nature.

RC Solve, an orange oil–derived solvent, has been reported to be non-irritating to soft tissues and periapical regions. In addition, it possesses a pleasant citrus aroma and demonstrates a relatively low rate of evaporation.[9] Eucalyptus oil, obtained from the leaves of *Eucalyptus globulus*, contains 1,8-cineole as its principal active component and is known for its anti-inflammatory and antibacterial properties.[10]Carvene is a solvent formulated with D-limonene as its primary constituent. This naturally occurring compound, commonly derived from the peels of citrus fruits and refined from orange oil, has been shown to be biocompatible and does not produce irritation to the oral mucosa or periapical tissues.[17]

The findings of the present study demonstrated that the premixed bioceramic sealer exhibited a certain degree of solubility in all three tested solvents. Among them, Carvene showed the highest dissolving efficacy, followed by RC Solve, while Eucalyptus oil exhibited the least effectiveness (Table 2).

At present, there are no standardized guidelines available for assessing the solubility of root canal sealers in organic solvents. Therefore, the methodology adopted in this study was based on protocols described in previously published research.[7] Earlier studies have reported that the mean time required for the removal of densely compacted obturating materials using instrumentation, with or without the assistance of solvents, ranges from approximately 1.5 to 10.8 minutes[18]; accordingly, an immersion period of 10 minutes was selected for this investigation.

Stainless steel rings were employed in place of extracted teeth to overcome the challenges associated with achieving uniformity in root canal length and diameter. Additionally, stainless steel is dimensionally stable and remains unaffected by the solvent action, thereby allowing accurate assessment of weight changes.[19] Each sealer specimen was used only once to improve measurement precision and to avoid potential weight variations that may occur due to repeated cycles of immersion and drying. Following the designated immersion period, all samples were rinsed with distilled water to eliminate any loosened or degraded debris.

Calcium silicate–based bioceramic sealers exhibit an alkaline pH as a result of calcium hydroxide formation, which occurs when calcium ions react with water. This leads to the development and deposition of calcium hydroxide crystals on the surface of the sealer. It may therefore be inferred that, upon immersion of the bioceramic sealer in essential oil–based solvents, the component primarily undergoing dissolution was calcium hydroxide.

Martos et al. reported that eucalyptus oil demonstrates lower efficacy in dissolving calcium hydroxide–based endodontic sealers compared with sweet orange oil.[20] These findings are consistent with the results of the present study, wherein D-limonene–based and orangewood oil–derived solvents exhibited significantly greater dissolving potential than eucalyptus oil.

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A limitation of the present study is that the in vitro immersion model employed may not precisely replicate clinical conditions. In a laboratory setting, the sealer is exposed uniformly to the solvent over its entire surface area, whereas under in vivo conditions, the material remains adhered to the canal walls and is only partially accessible to the solvent. Furthermore, clinically relevant variables such as intra-canal temperature, anatomical complexities, solvent exchange dynamics, and possible dilution or displacement by irrigants or biological fluids were not simulated in this experimental design. As a result, the outcomes of this study may not be directly applicable to clinical practice. Currently, no universal solvent fulfilling all ideal criteria has been identified, underscoring the necessity for continued research to develop more efficient and biocompatible alternatives.

CONCLUSION

Within the constraints of the present investigation, the following conclusions can be drawn:

1. Eucalyptus oil, orange oil, and D-limonene–based solvents demonstrated comparable effectiveness in dissolving the bioceramic sealer.
2. Among the solvents evaluated, eucalyptus oil exhibited relatively lower dissolving capacity compared with orange oil and D-limonene.
3. Further research is recommended to assess the influence of variables such as solvent temperature and the adjunctive use of ultrasonics on the dissolving efficiency of these agents when used for bioceramic sealer removal.

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