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ORIGINAL ARTICLE

J. Martos · M. T. Gastal · L. Sommer · R. G. Lund ·
F. A. B. Del Pino · P. W. R. Osinaga

Dissolving efficacy of organic solvents on root canal sealers

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Abstract The aim of this study was to evaluate the solubility of three types of root canal sealers in three organic solvents used in endodontics. The solubility of calcium-hydroxide-based (Sealer 26), silicon-polydimethylsiloxane-based (RoekoSeal), and zinc-oxide–eugenol based (Endofill and Intrafill) sealers was assessed in eucalyptol, xylol, orange oil, and distilled water. Eighty samples of each filling material were prepared according to the manufacturers' instructions and then divided into four groups for immersion in solvent for 2 or 10 min. The means of sealer dissolution in solvents were obtained by the difference between the original preimmersion weight and the postimmersion weight in a digital analytical scale. Data were statistically analyzed with the Student's *t* test, and multiple comparisons were performed with Student–Newman–Keuls. Xylol and orange oil showed similar effects, with significant solubilization ($P<0.05$) of the tested cements. Endofill and Sealer 26 did not show any significant difference in solubilization at the two immersion times, whereas RoekoSeal and Intrafill showed a more pronounced solubility at 10 min. The lowest levels of solubilization occurred in RoekoSeal, Sealer 26, Endofill, and Intrafill. It is concluded that xylol and orange oil presented similar solvent effects with a significant solubility of the tested cements.

Keywords Solubility · Sealers · Organic solvents

J. Martos (✉) · M. T. Gastal · L. Sommer · R. G. Lund
Department of Clinics, Pelotas Dental School,
Federal University of Pelotas,
Rua Gonçalves Chaves 457,
96015-560 Pelotas, Rio Grande do Sul, Brazil
e-mail: josue.sul@terra.com.br
Tel.: +55-53-2224439
Fax: +55-53-2224439

F. A. B. Del Pino
Department of Biochemistry, Chemistry Institute,
Federal University of Pelotas,
Pelotas, Brazil

P. W. R. Osinaga
Department of Operative Dentistry, Pelotas Dental School,
Federal University of Pelotas,
Pelotas, Brazil

Introduction

Despite being highly successful, some endodontic treatments do not respond to initial therapy for different reasons and, hence, retreatment becomes necessary. In most cases, retreatment is indicated due to improper cleaning and filling or due to lack of an efficient hermetic sealing, which enables the survival of bacteria inside dentinal tubules, apical ramifications, accessory canals, and secondary canals [1, 2].

Removal of endodontic filling material from the root canal is a requirement for retreatment [6, 11]. Several methods for removing the filling material—including the use of solvents, heat, and mechanical instrumentation, either alone or in combination [5, 8–10, 13, 23] with each other—are available. Gutta-percha, along with a variety of root canal sealers, is the most commonly used root canal filling material. It can be removed without great difficulty with the use of organic solvents or heated instruments [5, 14]. However, the sealer may resist dissolution, and complete removal may vary considerably [4, 12, 22].

Several commercially available endodontic sealers present different physicochemical characteristics, which could influence and consequently determine the clinical efficacy of any of the solvents [3, 12]. Some studies have suggested chloroform as the most effective solvent for most filling materials [7, 16, 17, 19–21]. It has been shown to have an excellent capacity for dissolution when compared to other solvents such as eucalyptol, xylol, or halothane [7, 16, 21].

Since it is important to use solvents that will not damage periapical tissues, the use of effective orange oil was proposed for the disintegration of zinc-oxide–eugenol (ZnOE)-based sealers [15]. The choice of an ideal solvent

Table 1 Mean percentage with SD (±) of weight loss for each sealer at different solvents and time

	Eucalyptus oil		Xylol		Orange oil	
Sealer	2 min	10 min	2 min	10 min	2 min	10 min
Intrafill	0.862±0.34[a]	1.381±0.50[a]	0.220±0.24[a,b]	0.913±0.43[a,c]	0.973±0.14[a]	1.869±0.89[a]
Sealer 26	0.028±0.49[b]	0.067±0.09[b]	0.174±0.092[a,b]	0.230±0.11[b]	0.108±0.07[a]	0.271±0.15[b]
Endofill	0.429±0.24[c]	0.509±0.32[c]	0.693±0.54[b]	1.138±0.56[a,c]	0.426±0.29[a]	0.876±0.44[b]
RoekoSeal	0.069±0.16[b]	0.001±0.03[b]	0.104±0.11[a]	1.286±0.83[c]	0.000	0.311±0.98[b]

Means followed by the same superscript letters in the column indicate no statistically significant differences ($P<0.05$)

for endodontic retreatment requires a balance between clinical safety in usage (substances with low toxicity and aggressivity towards tissues) and the highest chemical capacity for dissolution [18].

The study is based on the need for the removal of sealers from canal walls and apical ramifications using organic solvents for effective cleaning and disinfection. The aim was to compare the efficacy of three organic solvents commonly used in endodontics in solubilizing different root canal sealers.

Materials and methods

Four different sealers were included in this study: calcium-hydroxide-based/Sealer 26 (Dentsply, Rio de Janeiro, Brazil), polydimethylsiloxane-based/RoekoSeal (Roeko, Langenau, Germany), ZnOE-based/Intrafill (SS White, Rio de Janeiro, Brazil), and ZnOE-based/Endofill (Dentsply). Sealer cements were mixed in accordance with the manufacturers' instructions. Freshly mixed materials were carefully introduced into sample molds, and a microscope slide was then pressed onto the upper surface to make the surface flat. The calcium-hydroxide-based sealer was mixed with a spatula moistened with tap water. Standardized stainless steel molds with 8 mm diameter and 2 mm height were used to prepare 80 such samples of each sealer.

Ten minutes after the mixture was first prepared, the steel molds were transferred to a chamber with 80% relative humidity and 30±2°C temperature. The apparatus was left untouched for 48 h and then removed from the chamber. Excess material was then trimmed to the surface level of the mold with a scalpel, and residues were removed. The samples were weighed in grams (up to four decimal places) on an AG-200 precision scale (Gehaka, São Paulo, Brazil). The weights were recorded in triplicate.

The samples were then divided into four groups of 20 for immersion in eucalyptol (SS White), xylol (Labsynth, São Paulo, Brazil), orange oil (Dierberger, Rio Grande do Sul, Brazil), and distilled water. Each group was further divided into two equal subgroups (n=10) for 2 and 10 min of immersion.

At room temperature, sealer samples were immersed in 20 ml of solvent stored in an amber glass bottle with a screw cap (Corning Inc., New York, USA). The immersion was such that both surfaces of each sample were readily accessible to the solvent. Distilled water, obtained from a Milli-Q water system (Millipore Corp., Bedford, USA), was used as a negative solvent control. After the specified immersion period, samples were removed from the glass vial, rinsed with 100 ml of double-distilled water, and then blotted dry with absorbent paper. Samples were allowed to dry for 24 h at 37±1°C in an oven and then kept in a dehumidifier/desiccator. Thereafter, they were weighed, and the amount of sealer removed from the specimen was determined as the difference between the original weight of the sealer and its final weight.

The mean and standard deviation of percentage loss of weight were calculated at each time interval for each group of specimens. The values were compared by factorial

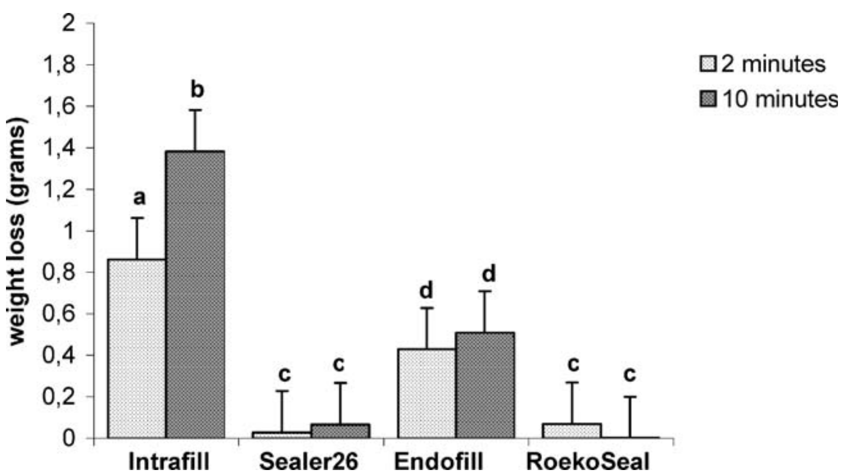

Fig. 1 Dissolution of sealers in eucalyptus oil over time. *Different letters* between samples represent statistically significant differences. *Identical letters* indicate no statistically significant differences between samples

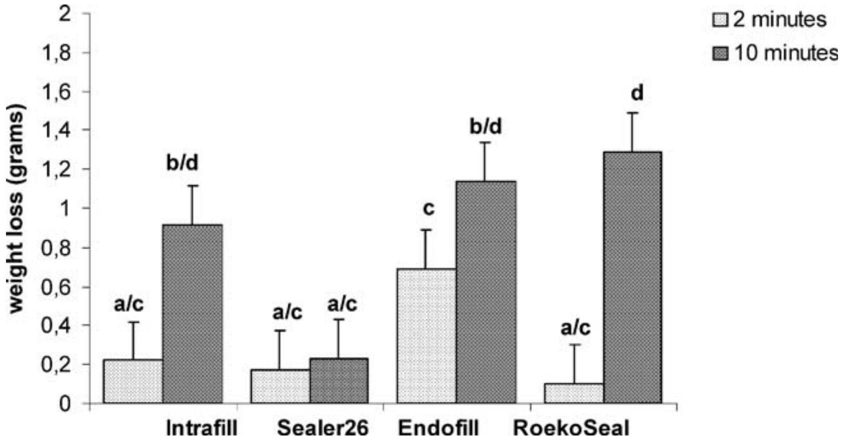

Fig. 2 Dissolution of sealers in xylol over time. *Different letters* between samples represent statistically significant differences. *Identical letters* indicate no statistically significant differences between samples

analysis of variance using the software SPSS 8.0 (SPSS nc., Chicago, USA), and the difference among the materials was calculated by Student's *t* test. Multiple comparison intervals were further performed to identify statistically homogeneous subsets ($P=0.05$) using post hoc Student–Newman–Keuls, with the value of statistical significance set at 0.05.

Results

Dissolution means and standard deviations recorded for the different solvents are summarized in Table 1. Xylol and orange oil had markedly superior ability for dissolving root canal sealers in comparison with the other solvents ($P<0.05$). Additionally, they showed statistical similarity in this ability to dissolve root canal sealers. In the distilled water control group, no sealer was dissolved.

Intrafill sealer presented a more pronounced solubility at 10 min ($P<0.05$) for all tested solvents (Figs. 1, 2 and 3), mainly for orange oil (1.869±0.98) followed by eucalyptol (1.381±0.50) and xylol (0.913±0.43). The calcium-hydroxide-based sealer (Sealer 26) and one of the ZnOE-based sealers (Endofill) did not show statistically significant differences at 2 or 10 min ($P>0.05$). However, they presented the highest disintegration score after immersion in xylol, orange oil, and eucalyptol.

RoekoSeal was significantly less soluble than other sealers ($P<0.05$) at all immersion times, except for xylol at 10 min (1.286±0.83). Multiple comparisons showed that the lowest levels of solubility and disintegration occurred in RoekoSeal, Sealer 26, Endofill, and Intrafill.

Discussion

Considering the great perspective of success in endodontic reinterventions, retreatment becomes a conservative clinical conduct in comparison with more radical procedures such as periapical surgeries. Although there are few reports in the literature regarding the solubility of endodontic cements immersed in organic solvents, the comparison of the effects on some groups of endodontic sealers observed in this study was interesting.

The effectiveness of xylol was similar to that of orange oil ($P<0.05$). However, some cements such as RoekoSeal and Sealer 26 suffered from lower disintegration in this solvent. For some sealers, some solvents had a more effective action in 2 min than others had in 10 min. Orange oil promoted an effective dissolution on ZnOE-based root canal sealer (Intrafill) in proportion to the contact time. Eucalyptol was similarly effective to xylol. The effectiveness of some less aggressive solvents, such as orange oil,

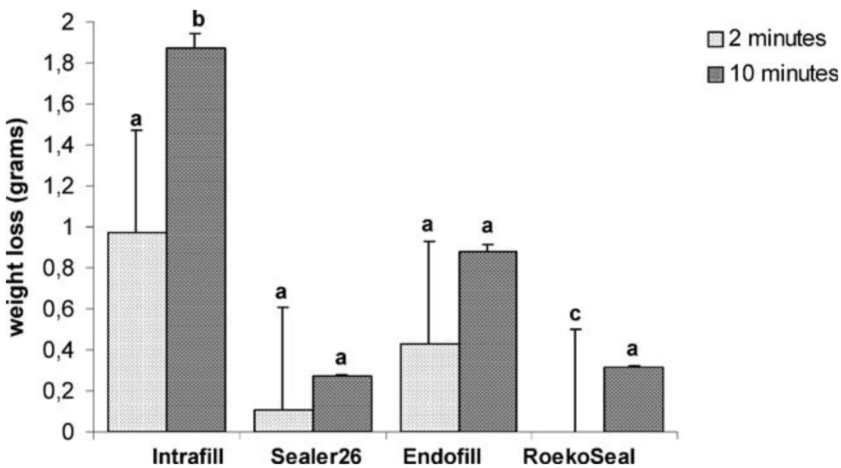

Fig. 3 Dissolution of sealers in orange oil over time. *Different letters* between samples represent statistically significant differences. *Identical letters* indicate no statistically significant differences between samples

on this type of cement is worth emphasizing. Orange oil at the initial time of 2 min was as effective as eucalyptol or xylol after 10 min of action.

The action of solvents, such as xylol (0.1138±0.05) or orange oil (0.0876±0.04), on Endofill was gradual and proportional to the contact time with the surface ($P<0.05$). But this did not happen with Eucalyptol (0.0509±0.03), which produced a similar solubility after 2 and 10 min. Whitworth and Boursin [21] observed that some ZnOE-based sealers presented low solubility to halothane, but a significant solubility to chloroform. This solvent proved to be nine times more efficient than eucalyptol when the tested cement was ZnOE, exposed for 20 min.

For improving their adhesive properties, most ZnOE-based filling cements have a high concentration of colophony in their composition. Colophony is a vegetable resin composed of approximately 90% of resinous acids and is soluble in solvents commonly used for endodontic retreatment. Pécora et al. [15] reported in their in vitro investigations that, with the use of orange oil, clearing of the root canal was approximately four times faster.

In these experimental conditions, RoekoSeal cement showed insignificant values of solvency in eucalyptol (0.0069±0.02), xylol (0.0104±0.01), and orange oil (0.000) during the first minutes of application. However, a significant change was observed with the use of xylol for 10 min ($P<0.005$). Possibly the plastic characteristic of this cement resulted in lower values of material loss by solvency. Some authors [3, 16] reported means with more significant values of insolubility of this material in eucalyptol as compared to that in chloroform. When immersed in eucalyptol for 20 min, some calcium-hydroxide-based endodontic sealers presented a solubility between 5.3 and 7.3% of their initial weight [16]. On the other hand, Whitworth and Boursin [21] reported a low solubility of calcium hydroxide cements in halothane and chloroform.

Nowadays, commonly used solvents have a good capacity for removing gutta-percha and also an effect on filling cements. There are several alternative auxiliary chemical agents for the dissolution of filling materials. These chemicals are chosen according to two fundamental criteria: solvent effectiveness and toxicity level [3, 18]. Besides the existence of alternative solvents to replace those with high levels of systemic and tissue-related toxicities, it is important to emphasize the possibility of other auxiliary methods—such as manual endodontic instruments, rotatory instruments, and equipment such as ultrasound—removing the cement [5, 8–10, 13, 23].

In some previous studies, chloroform, as well as gutta-percha [19, 20], was reported to be the solvent with the greatest capacity for dissolving most endodontic cements [16, 21]. Görduysus et al. [7] verified that xylol, when compared to chloroform, also exhibited a similar capacity for gutta-percha dissolution. While evaluating the effectiveness of different solvents in softening gutta-percha, Oyama et al. [14] verified that both xylol and orange oil presented excellent results. This fact is important as gutta-percha is a rubber-like plastic material and its softening is facilitated by the solvent, which allows easier penetration and movement of the manual endodontic instrument in order to remove the cement.

Despite the absence of specific standards for the measurement of endodontic solvents on filling materials, experimental observations of the superficial effects of endodontic solvents were possible, taking into consideration some important aspects in the methodology such as solvent effect time, use of commonly employed materials, temperature, and contact surface upon which the solvent will act.

Considering the efficiency and similarity between xylol and orange oil ($P>0.05$), we could presume an extension of the clinical use of the latter due to its low toxicity to the tissues. The field of action of a solvent must primarily be limited to the proximity of the periapex in order to prevent the occurrence of chemical pericementitis. Thus, careful utilization of the solvent, as well as the use of short gauge and active endodontic files, to facilitate the chemical–mechanical removal of endodontic cements is essential.

Conclusions

Within the limitations of this in vitro investigation, we were able to conclude that:

- Xylol and orange oil presented similar solvent effects, with a significant solubility of the tested cements. Eucalyptol presented a superior solvent effect only when compared to the control group.
- Endofill and Sealer 26 did not show significant differences in solubility in either tested immersion times, while RoekoSeal and Intrafill showed a more pronounced solubility in 10 min.

References

1. Bergenholtz G et al (1992) Retreatment of endodontic fillings. Scand J Dent Res 87:217–224
2. De Deus QD (1975) Frequency, location and direction of the lateral, secondary and accessory canals. J Endod 11:361–366
3. Erdemir A, Adanir N, Belli S (2003) In vitro evaluation of the dissolving effect of solvents on root canal sealers. J Oral Sci 45:123–126
4. Friedman S, Moshonov J, Trope M (1992) Efficacy of removing glass ionomer cement, zinc oxide eugenol, and epoxy resin sealers from retreated root canals. Oral Surg Oral Med Oral Pathol 73:609–612
5. Friedman S, Stabholz A, Tamse A (1990) Endodontics retreatment—case selection and technique. Part 3. Retreatment techniques. J Endod 16:643–649
6. Friedman S, Moshonov J, Trope M (1993) Residue of gutta-percha and a glass ionomer cement sealer following root canal retreatment. Int Endod J 26:169–172
7. Görduysus MÖ, Tasman F, Tuncer S, Etikan I (1997) Solubilizing efficiency of different gutta-percha solvents: a comparative study. J Nihon Univ Sch Dent 39:133–135
8. Jeng H, ElDeeb ME (1987) Removal of hard paste fillings from the root canal by ultrasonic instrumentation. J Endod 13:295–298
9. Krell KV, Neo J (1985) The use of ultrasonic endodontic instrumentation in the re-treatment of a paste-filled endodontic tooth. Oral Surg Oral Med Oral Pathol 60:100–102

10. Ladley RW, Campbell AD, Hicks ML, Li SH (1991) Effectiveness of halothane used with ultrasonic or hand instrumentation to remove gutta-percha from the root canal. J Endod 17:221–224
11. Mandel E, Friedman S (1992) Endodontic retreatment: a rational approach to root canal reinstrumentation. J Endod 16:565–569
12. Moshonov J, Trope M, Friedman S (1994) Retreatment efficacy 3 months after obturation using glass ionomer cement, zinc oxide–eugenol, and epoxy resin sealers. J Endod 20:90–92
13. Mounce R (2004) Current concepts in gutta-percha removal in endodontic retreatment. N Y State Dent J 70:3235
14. Oyama KON, Siqueira EL, Santos M (2002) In vitro study of effect of solvent on root canal retreatment. Braz Dent J 13:208–211
15. Pécora JD, Costa WF, Filho DS, Sarti SJ (1992) Apresentação de um óleo essencial, obtido de *Citrus aurantium*, eficaz na desintegração do cimento de óxido de zinco–eugenol do interior do canal radicular. Odonto 1:130–132
16. Schäfer E, Zandbiglari T (2002) A comparison of the effectiveness of chloroform and eucalyptus oil in dissolving root canal sealers. Oral Surg Oral Med Oral Pathol 93:611–616
17. Schuurs AH, Moorer WR, Wesselink PR (2004) Solvents for removal of gutta-percha from root canals. I. Efficacy. Ned Tijdschr Tandheelkd 111:271–275
18. Schuurs AH, Moorer WR, Wesselink PR (2004) Solvents for the removal of gutta-percha from root canals. 2. Side effects of chloroform, halothane and xylene. Ned Tijdschr Tandheelkd 111:303–306
19. Tamse A, Unger U, Metzger Z, Rosenberg M (1986) Gutta-percha solvents—a comparative study. J Endod 12:337–339
20. Wennberg A, Orstavik D (1989) Evaluation of alternatives to chloroform in endodontic practice. Endod Dent Traumatol 5:234–237
21. Whitworth JM, Boursin EM (2000) Dissolution of root canal sealer cements in volatile solvents. Int Endod J 33:19–24
22. Wilcox LR (1995) Endodontic retreatment with halothane versus chloroform solvent. J Endod 21:305–307
23. Wilcox LR, Krell KV, Madison S, Rittman B (1987) Endodontic retreatment: evaluation of gutta-percha and sealer removal and canal reinstrumentation. J Endod 13:453–457