# USE OF ORGANIC SOLVENTS IN ENDODONTICS: A REVIEW

## *Utilização de solventes orgânicos em endodontia: revisão*

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## *Abstract*

Endodontic re-treatment is a conservative clinical conduct in comparison with more radical procedures. Removal of endodontic filling material from the root canal is an essential requirement for retreatment. The aim of this study is to review the literature about the use of solvents in endodontic retreatment

**Keywords**: Organic solvents; Filling material; Endodontic retreatment.

## *Resumo*

O retratamento endodôntico é conduta clínica conservadora quando comparada a procedimentos mais radicais. A remoção do material obturador do canal radicular é uma exigência para o retratamento. O objetivo deste trabalho é revisar a literatura sobre a utilização de solventes no retratamento endodôntico.

**Palavras-chave**: Solventes orgânicos; Material obturador; Retratamento endodôntico.

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## Introduction

A certain number of cases do not respond to initial endodontic therapy for many reasons; retreatment becomes necessary (1). The main causes of endodontic failure are improper cleaning and filling of the root canal system, procedural errors, or the lack of an efficient hermetic sealing, which enables the survival of bacteria inside dentinal tubules, apical ramifications, accessory and secondary canals (2, 3, 4).

Retreating previously filled canal systems demands that antimicrobial irrigants and medicaments gain access to all ramifications of the canal system which may be harbouring organic matter and microorganisms. It is desirable that all materials employed are amenable to complete removal during retreatment (5).

Various removal methods are available, including the use of solvents, heat and mechanical instrumentation, alone or in combination (6). Gutta-percha, in combination with a variety of sealers, is the most commonly used material for root canal filling (7). Removal techniques are dependent upon canal size and anatomy, canal third, well condensed or aged gutta-percha, quantity of gutta-percha present and whether the existing gutta-percha is over or under-extended relative to the apical foramen (8, 9). Sealers used in conjunction with gutta-percha may remain inaccessible to mechanical removal when they are in anatomical ramifications (10, 11). In such cases, solvents are essential for the thorough cleaning of filling material/debris and effective disinfection of the root canal system (11).

There are also dangers of using purely mechanical means to remove gutta-percha, as root perforation, canal straightening, or altering the original canal shape (12). Removal of filling materials is greatly simplified by the use of solvents.

The aim of this study was to review the literature about the use of solvents in endodontic retreatment.

### Action of the solvents on gutta-percha

Chloroform and halothane were tested in conjunction with hand file or ultrasonic instrumentation. No significant difference in amount of debris extruded, neither in time required to remove root canal filling was found. Ladley et al. (8) suggested that halothane is an acceptable alternative to chloroform. Gutta-percha dissolution was tested using Gates-Glidden drills and K-flex files in conjunction with solvent and confirms that chloroform dissolved gutta-percha faster than halothane (13, 14) .

Zakariasen et al. (15) described a retreatment technique which involves the combination of heat from the instrument and the heat-potentiated solvent action of the eucalyptol that allows complete, rapid softening and removal of gutta-percha throughout the entire root canal system. Eucalyptus oil and orange oil associated to files were tested by Limongi et al. (16). There was not statistical difference, but eucalyptus oil tended to show cleaner root canal walls on middle third.

It was tested if chloroform, halothane, eucalyptus oil, oil of melaleuca, white pine oil and pine needle oil could partially (50-95%) or completely (>95%) dissolve gutta-percha in 20 minutes at 37ºC. Kaplowitz (17) found that just chloroform and turpentine oil completely dissolved gutta-percha. In 1991, Kaplowitz (18) tested 17 essential oils at 37ºC for 10 minutes. Chloroform and rectified turpentine oil complete dissolved gutta-percha. In 1994, Kaplowitz (19) tested rectified turpentine oil at room temperature and at 158ºF (70ºC). At room temperature turpentine failed to completely dissolve gutta-percha and warmed to 158ºF, gutta-percha was completely dissolved.

Thirty-one solvents were tested by Wourms et al. (12). If the solvent took longer than 15 minutes to dissolve the sample it was considered insoluble. At 22ºC, chloroform, trichloroethylene and tetrachloroethylene dissolved gutta-percha. At 37ºC chloroform, trichloroethylene, tetrachloroethylene, xylene, methylchloroform, COE ® paste remover, halothane, orange oil and cineole were able to dissolve gutta-percha. Chloroform had the fastest time of removal.

Some authors weighted gutta-percha before and after immersion in solvents. Della Nina et al. (20) reported that chloroform, xylene, eucalyptol, turpentine, ether, acetone and benzine softened gutta-percha after 30 minutes. Xylene was the most efficient and acetone and turpentine had the slowest action. Görduysus et al. (21) found that halothane is an appropriate, equal and acceptable alternative to chloroform and xylene. Tanomaru Filho et al. (22) tested orange oil, xylol, eucalyptol and d-limonene. Xylol was the most effective

solvent. Bueno and Valdrighi (23) weighted gutta-percha points before and after immersion in chloroform, xylol, halothane, eucalyptol, turpentine and orange oil. In 5 minutes, chloroform, xylol and halothane were equal. In 10 minutes, chloroform dissolved best the gutta-percha. Oyama et al. (1) found that in 5 minutes xylene had the faster solvency. In 15 minutes decrescent solvency was showed by orange oil, xylene, eucalyptol and halothane, but they were not statistically different.

Three brands of gutta-percha were analysed for weigth loss after immersion in solvents at 37 ºC by Tamse et al. (24) and Metzger et al. (25). These two studies found that DMS ® was the most soluble, followed by Hygienic ® and DeTrey. The authors related that master cones were more soluble than accessory cones. Metzger et al. (25) reported a decrescent order of solvency ability: chloroform, xylene and Hemo-De ®. They also suggest that Hemo-De (® is a potential substitute to xylene. Tamse et al. (24) conclude that chloroform was the most effective, followed by xylene, Endosolv-E ® and orange oil.

Wennberg and Orstavik (26) measured the depth of penetration of a small indentor in gutta-percha discs. The decrescent depth penetration in gutta-percha discs was chloroform followed by methylene chloride, tetrahydrofuran, methyl-chloroform and xylene. Eucalyptol was the least effective; it required 10 minutes to produce what others produced in 1 minute. In 1991, Hunter et al. (27) related that eucalyptol and halothane are alternatives to chloroform. They performed two tests, with hand file technique and a device providing a constant force to test if chloroform, halothane and eucalyptol could penetrate glass funnels filled with gutta-percha. All solvents softened gutta-percha to allow 10mm of penetration in less than 70 seconds.

**Action of the solvents on different sealers**

Erdemir et al. (28) tested the time required to pass a file through the end of glass tubes (15 mm) full of sealer using chloroform, halothane and just file without solvent. AH26 ® and AHPlus ® were not removed within 30 minutes. Sealapex did not set at all. RoekoSeal ® was easily removed by all techniques. Diaket ® was removed with chloroform and halothane, but it was not removed without solvent. Sankin Apatite ® showed no advantage in using solvents and for Sultan ® the solvents were very effective taking 40 seconds while the files took 2.1 minutes.

Some researches (2, 3, 5, 22) immersed the samples in solvents at room temperature and weighted them before and after immersion. Whitworth and Boursin (5) tested chloroform and halothane. Ketac Endo ® was the least soluble sealer. AHPlus® was the most soluble material, followed by TubliSeal ®and Apexit®. Chloroform had better results than halothane. Schäfer et al. (3) tested eucalyptol and chloroform. Ketac Endo® and RoekoSeal ® were related to be nearly insoluble. For chloroform, the weight loss in decrescent order was: AHPlus®, Diaket®, Apexit®, Sealapex,® AH26® RoekoSeal® and Ketac Endo.® For eucalyptol the weight loss of all sealers was less than 10%.

Martos et al. (2) tested xylol, eucalyptol and orange oil. The slowest levels of solubilization occurred in RoekoSeal®, Sealer 26®, Endofill,® and Intrafill®Xylol and orange oil showed similar effects, with significant solubilization of the tested cements. Tanomaru Filho et al. (29) related that eucalyptol and xylol showed more effective action for Intrafill, mostly the xylol, and little or no action for AHPlus®, Epiphany, Endo-Rez® and RoekoSeal.®

Ibarrola et al. (30) reported that Thermafill/Thermaseal® could easily be removed from canals with K-files in conjunction with chloroform, halothane and xylene in 2 to 3 minutes, while eucalyptol took 5 to 6 minutes to do it.

**Action of the solvents on gutta-percha associated to endodontic sealers**

Wilcox et al. (31) tested four methods for retreatment: heat and files; heat, files and Cavi Endo® chloroform and files and chloroform, files and Cavi Endo®.The sealers AH26® and Roth's 801® sealer in conjunction with gutta-percha were tested. For AH26 the last method was less effective and for Roth's 801® the first method was less effective. Roth's 801 presented cleaner canal walls than AH26® Most of the debris remainders consisted of sealer.

A solvent associated to Canal Finder was tested by Galvão de Souza and Bramante (32). Root canals were obturated with gutta-percha and zinc-oxide eugenol based sealer. All the teeth showed

remainders of filling materials and there was not statistical difference related to time. The solvents which had more apical extruded material were consecutively xylol and eucalyptol/chloroform (33).

Oliveira et al. (7) used gutta-percha/ AH26® and Resilon/Epiphany® in their study. The techniques used were K3 files and Liberator files, and both techniques in conjunction with chloroform. Resilon/Epiphany ®was removed faster than gutta-percha/AH26 and K3 files left less residual filling material.

Pécora et al. (34) used a penetrometer and recorded the time that the file took to penetrate 20 mm of gutta-percha and zinc oxide eugenol based sealer. The faster solvents were chloroform, followed by xylol and orange oil, turpentine, eucalyptol. Spanó et al. (35) also used a penetrometer in their study. Solvents alone and associated two by two at room temperature were studied to evaluate the ability of softening gutta-percha/zinc-oxide eugenol based sealer. The solvents were ordenated from the most to the least effective solvent as follows: chloroform and orange oil/turpentine; orange oil; orange oil/eucalyptol; turpentine; turpentine/ eucalyptol and eucalyptol.

Hansen (6) tested chloroform, xylol, eucalyptol and orange oil. A Hedströen file had to penetrate the lenght of the tubes (15 mm) obturated with gutta-percha and AH26,® ProcoSol ®or Sealapex ®until 40 min. Only chloroform dissolved AH26 in 40 minutes. Uemura et al. (36) tested the effectiveness of eucalyptol and d-limonene to dissolve the sealer Tubli-Seal ®associated with gutta-percha, Obtura II®,Ultrafil® system and Thermafil® obturators. There was not difference on the time required to the tip of the Hedströen to reach the apex. However, the time for the reamer to remove the filling material was affected both by the filling techniques and the solvents used. Thermafill ®was somewhat more resistant to be removed and chloroform was able to clean it more quickly.

Oyama et al. (1) measured the penetration of a spreader while applying force after the solvents acted for 5 minutes on gutta-percha/N-Rickert®. The solvents tested were chloroform, xylol, halothane, eucalyptol and orange oil. Xylol and orange oil required the smallest amount of force to penetrate the lenght in time.

Eucalyptol, dimethylformamide and no solvent were used in conjuction with Nd:YAG laser to soften gutta-percha/Diaket. Rretreatment was considered complete when the tip of laser reached the working lenght. Viducic et al. (37) reported that Nd:YAG laser is capable of softening gutta-percha *in vitro*, but the addition of solvent did not improve its removal, either in terms of the time required for the procedure or in terms of remaining gutta-percha on root canal walls.

Friedman et al. (10) compared hand instrumentation/chloroform and ultrasonic/hand instrumentation/chloroform to remove gutta-percha associated with AH26®, Roth's 801®or Ketac Endo.® Ultrasonic method was faster than hand instrumentation. Chloroform or orange oil in conjunction with a spreader were tested by Pécora et al. (38) to soften gutta-percha/zinc oxide-eugenol based sealer. The chloroform group took 25 minutes, while the orange oil group took 6 minutes.

Hülsmann and Stolz (4) tested five techniques to remove gutta-percha/AH26® sealer and founded that XGP drill and Gates-Glidden associated with Hedströen files showed better results. Gilbert et al. (39) related that a small reamer or file can be worked down alongside the silver cone with the use of solvent to remove the sealer. Although it is a rather slow process, the success of this method justifies the time spent. If, on attempts with a file, a linear void is not found, then solvents may be used to remove gutta-percha. Mounce (9) related that chloroform is indispensable in narrow, curved and canals that have not been ideally prepared, especially in the apical third. Chloroform is the gutta-percha solvent of choice at this time. Schwandt et al has studied chloroform as the solvent of choice for the so called resin "Russian red" (resorcinol-formaldehyde resin) (40)

According to Cucco et al. (41) eucalyptol is mainly efficient on softening gutta-percha and orange oil is mainly efficient in dissolving zinc oxide eugenol based sealer.

Due to a Food and Drug Administration (FDA) ban on drugs and cosmetics containing chloroform, there has been some confusion as to whether the use of chloroform in the practice of dentistry is considered unsafe or has been prohibited. A clinical investigation was performed by McDonald and Vire (42) in which two patients who were deemed to benefit from chloroform were appointed for treatment. The air samples were found to be well below the permissible exposure limit-time-weighted average for chloroform, therefore eliminating any health hazard.

It is important to remember that only ban on chloroform is for use in drugs or cosmetics close repeated contacted exposure to the skin may pose a potential for it becoming carcinogen (42). Chutich et al. (43) assessed the toxicity of chloroform, halothane and xylene through a quantification of apically extruded solvent. The results indicate that the amount of solvent that has been leached out through the apical foramen is several orders of magnitude below the permissible dose.

Barbosa et al. (44) dissolved 2.5 grams of gutta-percha in 5 mililiters of chloroform, halothane and turpentine and spread them over mouse fibroblasts cell culture. All solvents were toxic. Turpentine showed higher toxicity than chloroform and halothane. Scelza et al. (11) exposed mice peritoneal macrophages to chloroform, eucalyptol and orange oil for 30 minutes. All solvents were cytotoxic. Orange oil showed less cytotoxicity. Chloroform and eucalyptol were tested on hamster ovary cells. Ribeiro et al. (45) reported that both solvents were cytotoxic. Vajrabhaya et al. (46) tested chloroform and *d*-limonene in cell line L929. Both solvents proved toxic at 1:100 and 1:400. At the dilution of 1:800 *d*-limonene seemed to be more toxic than chloroform. Philipps and Vizioli (47) studied the biocompatibility of chloroform, eucalyptol and orange oil in mice subcutaneous tissue. Chloroform and eucalyptol did not show statistical difference and the orange oil was the least irritant.

## Conclusion

There is a wide variation of results among endodontic solvents tested in the literature. It occurs because there is not a standard model to perform the tests; each author establish the materials that will be tested, interval of time, temperature and the device used to measure the results.

In some articles the samples tested were natural teeth sealed with filling material, gutta-percha cones, gutta-percha or sealer molds. The time that natural teeth obturated with filling material were stored before performing the endodontic retreatment varied from seven days to twenty-four months. When the endodontic filling is gutta-percha, different solvents were capable of efficiently dissolve it. However, to dissolve sealers the solvent showed more difficulty and chloroform was cited as the most efficient. Some sealers are described as nearly insoluble by solvents.

The majority of endodontic filling materials are easily removed with the use of solvents. So, when doing endodontic treatment, professionals should consider the use of materials that are easily removed in case of retreatment.

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Received in: 10/25/2006
*Recebido em*: 25/10/2006
Accepted in: 11/20/2006
*Aceito em*: 20/11/2006