In Vitro Study of Effect of Solvent on Root Canal Retreatment

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The aim of this study was to assess the effectiveness of five different solvents: xylol, eucalyptol, halothane, chloroform and orange oil on softening gutta-percha in simulated root canals. One drop of solvent was placed into a reservoir made in a simulated canal whose channel was previously instrumented and filled with gutta-percha and N-Rickert sealer. After 5 min, softening was evaluated for each solvent by the penetration of a spreader while applying force with a 442 Instron apparatus to reach a depth of 5 mm. The results were analyzed statistically by the Kruskal-Wallis test. Xylol and orange oil were better in softening gutta-percha than the other solvents. There was no significant difference between xylol and orange oil, but these were statistically different from eucalyptol, halothane and chloroform ($p<0.01$).

Key Words: gutta-percha solvents, organic solvents, root canal retreatment.

INTRODUCTION

The success rate of endodontic therapy is between 62% and 96% (1). This indicates that a certain number of cases do not respond to initial therapy for many reasons and thus retreatment becomes necessary.

Gutta-percha has been used in endodontic therapy for more than 100 years and is still the principal material for filling root canals (2,3). Thus, endodontic retreatment fundamentally consists of the removal of gutta-percha cones from inside root canals.

Knowing the risk of the use of purely mechanical means to remove gutta-percha, such as perforation, fracture or alteration of the original root form, several techniques have been proposed seeking efficiency, speed and practicality in gutta-percha removal. These include the use of heated instruments, of microscopes, or of manual instruments either by themselves or combined with sonic apparatuses or Gates-Glidden drills in the cervical third. The use of solvents is necessary for all techniques for removal of gutta-percha (4-9).

Chloroform and eucalyptol have been used as solvents since 1850 (4). Chloroform, although an excellent solvent, is highly toxic and has carcinogen potential; its clinical use has been prohibited in humans since 1976 (10). Studies confirm that substances, when placed in the tooth pulp chamber, have access to periapical tissue and the circulatory system (11). Xylol and eucalyptol are the most commonly used solvents by professionals. Wennberg et al. (3) reported that xylol was the most efficient in dissolving gutta-percha cones. However, according to Wourms et al. (4), xylol has a toxic effect on tissues. Pécora et al. (12), examining gutta-percha softening, reported that xylol causes irritation to the mucosa through contact and, through inhalation, could also cause convulsions, insomnia, excitement and repression of the CNS, as well as lead to death by respiratory repression.

Trying to minimize this conflict between effectiveness and toxicity, eucalyptol, a widely used substance for flavoring and fragrance, has been used as a solvent without harmful effects (12). However, studies testing the performance of some alternatives to chloroform conclude that, at room temperature, eucalyptol dissolves very slowly in comparison to other solvents (2). When it is heated, its dissolution effect increases (13).

Halothane, a relatively non-toxic, volatile, non-flammable fluorethane hydrocarbon, has been used as

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an inhalation anesthetic since 1956. It has a sweet smell, is slightly soluble in tissues and has minimal solubility in blood. In spite of the fact that it is not a respiratory irritant, it needs to be used carefully to minimize its exposure to the environment due to its ability to cause respiratory repression (4). The high volatility of halothane can be desirable, because it decreases the quantity of residual solvent in the periapical region and circulatory system (11).

Orange oil was initially presented as an essential oil disintegration solvent of zinc oxide and eugenol sealer (14). Pécora et al. (12) reported that orange oil softened gutta-percha cones in endodontic retreatment with results similar to xylol and could be used as an alternative solvent.

In light of current knowledge about gutta-percha solvents, we know that the most efficient solvents chloroform and xylol are also the most toxic. It is thus appropriate to continue the search for a product that can satisfactorily dissolve gutta-percha, without presenting undesirable effects. Thus, the purpose of this study was to evaluate several products that can dissolve gutta-percha, assessing the softening of the filling in simulated canals as measured by the penetration of a spreader while applying force.

MATERIAL AND METHODS

Sixty simulated canals were used. They were instrumented by the crown-down technique, using Gates-Glidden drills and manual K-files until obtaining an apical preparation with #60 file. They were filled with gutta-percha cones (Dentsply, Petrópolis, RJ, Brazil) and N-Rickert sealer (Fármácia Fórmula e Ação, São Paulo, SP, Brazil) by lateral and vertical condensation. Two millimeters of gutta-percha were then removed from all canals in order to create a reservoir to deposit the solvent to be tested. The simulated canals were then distributed into 6 groups according to the solvent used (1 drop): group 1: xylol, group 2: eucalyptol, group 3: orange oil, group 4: halothane in a one to one proportion to propyleneglycol, group 5: chloroform, and group 6: negative control.

The test of penetration was achieved in a 4442 Instron apparatus (Instron Corp., Canton, MA, USA) that has two bases, an upper, movable one and a lower, fixed one (Figure 1A). For this study, two calipers were custom-made and adapted, one to the upper base, where a #30 digital spreader was connected, and the other to the lower base with a caliper to hold the simulated canal (Figure 1B). Thus, by means of vertical movement of the mechanism on a single axis generated by the apparatus itself, it was possible to measure the necessary force for the digital spreader, with a constant speed of 5 mm/min, to penetrate to a depth of 5 mm into the gutta-percha in the simulated canal 5 min after the application of a drop of the solvent being tested.

The values of force exerted were analyzed by the Kruskal-Wallis test ($p<0.01$).

RESULTS

Xylol (4.473 ± 0.226) and orange oil (5.029 ± 0.143) required the smallest amount of force to penetrate to the length and in the time desired. They were statistically similar. Halothane (6.221 ± 0.260), chloroform (6.378 ± 0.364) and eucalyptol (5.973 ± 0.111) did not show a statistically significant difference when compared to each other, but, when compared to xylol and orange oil, there was a statistically significant difference. The control group (8.428 ± 0.191) required

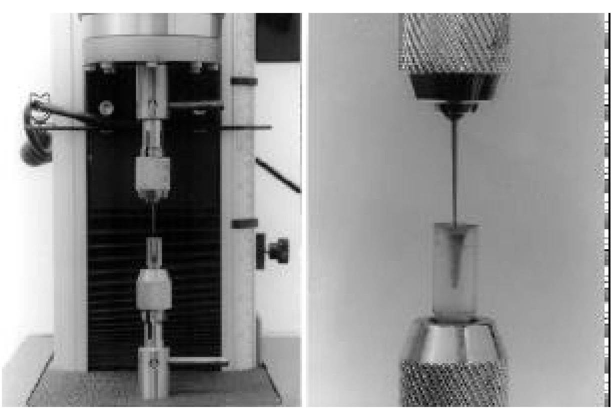

Figure 1. Left: Instron apparatus used for the test of penetration. Right: Digital spreader is connected within upper caliper and simulated canal is fixed by lower caliper.

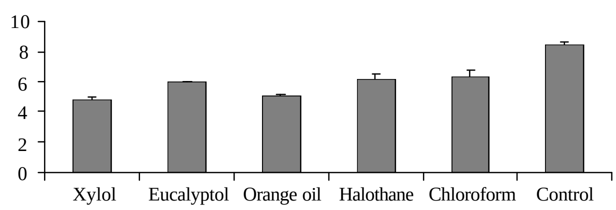

Figure 2. Average force (MPa) required to penetrate 5 mm into gutta-percha in a simulated canal 5 min after the application of one drop of solvent.

the greatest force for penetration, with statistically significant values when compared to the other experimental groups.

The mean values of the force applied in the experimental groups are shown in Figure 2. The normal curve adherence test showed abnormal distribution. Therefore, Kruskal-Wallis test was also used ($H = 30.9469$, $\chi^2 = 30.95$ for 5 degrees of liberty, $p = 0.01$).

DISCUSSION

The aim of this study was to classify the solvents as to effectiveness and related toxicity. According to our findings, all solvents showed softening action of gutta-percha cones within 5 min.

In spite of being considered a good solvent due to its characteristic high volatility, halothane forms a viscous material when in contact with gutta-percha cones (4). Thus, we tried to minimize the volatilization effect in our study by introducing a dense viscous vehicle: polyethyleneglycol in a one to one proportion. Despite this, there was a volatilization effect. According to Hunter et al. (11), 1 ml of halothane introduced into a simulated canal orifice evaporates in 21 min. However, in a previous study we observed that the same quantity of pure halothane evaporated quickly and a reduction of the quantity of halothane may have resulted in decreased softening action. High volatility can be desirable to clinicians that are concerned about the quantity of residual solvent that could enter the periapical region and circulation system, but it can be a disadvantage if the solvent evaporates before the gutta-percha cones are sufficiently softened. In the choice of a retreatment solvent, a balance between the time of use and safety must be reached.

In the present study, xylol proved to be the most efficient. A comparative study of the dissolving efficiency of different solvents reported that xylol presents results similar to those of chloroform and halothane (15). Our results, however, showed that these two solvents were the least effective, perhaps due to their volatility. Some authors mention the high toxicity of chloroform and xylol and suggest that orange oil and halothane are efficient alternatives at a temperature of 37°C (4). Pécora et al. (14) presented orange oil as an alternative solvent without deleterious effects and with the same softening action as xylol, and our results confirm that orange oil is efficient and has an effect similar to xylol. Its toxicity, however, will need more detailed study.

Evaluation of chloroform use in dental practice showed that controlled and careful use can be valuable. The Food and Drug Administration does not have jurisdiction to prohibit the use of chloroform by dentists and does not have proof that it is carcinogenic to humans (16). Chutich et al. (17) demonstrated that it does not have a toxic risk in patients when a minimal quantity of solvent is used. It should be noted, however, that much larger amounts of chloroform must be used than other solvents studied due to its volatility.

We also noted that each of the solvents tested evaporated at different times even though the same amount of solvent was used for each test. Both pure halothane and chloroform evaporated very quickly due to their volatility (chloroform evaporated almost completely after a minute of contact with air), and thus both needed almost constant replacement in order to sufficiently soften the gutta-percha cones.

Considering the toxic and carcinogenic effects of some solvents, this study shows that substances which fulfill the requirements of speedy action, harmlessness to the tissues adjacent to the tooth, a pleasant smell and non-toxicity to the professional, the patient and the environment such as orange oil should be indicated for endodontic retreatment.

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RESUMO

Oyama KON, Siqueira EL, dos Santos M. Efeito *in vitro* dos solventes no retratamento. Braz Dent J 2002;13(3):208-211.

O objetivo deste trabalho foi avaliar a efetividade de cinco diferentes solventes: xilol, eucaliptol, halotano, clorofórmio e óleo de laranja em amolecer a guta percha nos canais simulados. Uma gota de solvente foi colocada dentro do reservatório, realizado em canal simulado, cujo canal foi previamente instrumentado e obturado com guta percha e cimento N-Rickert. Após a ação de 5 minutos, o amolecimento foi avaliado para cada solvente através de penetração de um espaçador enquanto a força aplicada alcançava uma profundidade de 5mm. Os resultados foram analisados estatisticamente pelo teste Kruskal-Wallis. Não existiu diferença estatisticamente entre xilol e óleo de laranja, mas estes foram estatisticamente diferentes quando comparados ao eucaliptol, halotano e clorofórmio ($p<0{,}01$). Xilol e óleo de

laranja mostraram ser melhor que outros solventes em amolecer guta percha.

Unitermos: solventes de guta percha, solventes orgânicos, retratamento de canal radicular.

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