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Research Article

Gutta-Percha Solvents Alternative to Chloroform: An *In Vitro* Comparative Evaluation

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Abstract

Objective: Chloroform is an organic solvent extremely effective in dissolving the gutta-percha, but it is a potential carcinogen. The aim of this study is to compare the effectiveness of different alternative solvents with ability to dissolve gutta-percha that can be regarded a practicable alternative to chloroform.

Materials and Methods: Stainless steel ring molds were used to create 50 gutta-percha samples. Each sample was dipped in different solvents: chloroform, Orange solvent, a mixture of D-limonene and 1,2 dichloropropane, a mixture D-limonene and turpentine, essence of turpentine. The weight loss after immersion was registered and solubility efficacy of each solvent was calculated.

Results: Numeric data were analyzed by Shapiro Wilk test, Kruskal-Wallis analysis of variance test and Mann-Whitney post-hoc test, and significance was set at P value < 0.05. The analysis of the results showed that chloroform had the greatest solubilizing effect and the ability to dissolve gutta-percha was significantly lower ($p < 0.05$) in the other groups.

Conclusions: This study confirmed that chloroform is the most effective solvent. Other solvents, such as G.P.R and Orange Solvent, could be considered an alternative to chloroform even if less efficient.

Keywords: *Chloroform; Endodontic Retreatment; Gutta-Percha; Solvents*

Introduction

Schilder introduced the term "retreatodontics" to indicate the branch of endodontics in charge of reprocessing an endodontic treatment in orthograde (conservative) or retrograde (surgical) way [1]. The orthograde non-surgical retreatment is the repetition of a primitive incorrect endodontic treatment and the main objective is to remove all the filling materials from the root canal system and to regain the access to the apical third in order to perform a new correct treatment [2,3]. A retrograde surgical treatment is the choice when the proper orthograde therapy is not possible or has already failed, but when the tooth is seriously compromised, dental extraction is the only solution [3].

The retreatment is indicated when clinical symptoms are present, when radiographic signs of failure are shown, when the tooth have to be included in a prosthetic restoration and endodontic treatment is incomplete even if clinical or radiographic signs are not present [3]. The retreatment requires the complete removal from root canal space of the filling material, usually made by the association of gutta-percha and some endodontic cement [3-6]. The effectiveness of this procedure is guaranteed by the removal of the total amount of the sealer and the gutta-percha from an inadequately shaped and filled root canal system because it's critical for uncovering remnants of necrotic tissue or bacteria and they have to be exposed to a more efficient chemo-mechanical disinfection procedure [7,8].

Several methods are used for softening or partially dissolving gutta-percha, including the use of stainless steel hand files, nickel-titanium (NiTi) rotary instruments, heat-bearing instruments and ultrasonics [9]. In addition, the use of a solvent is recommended to facilitate the removal of gutta-percha by softening it without damaging the tooth [10,11]. Organic solvents have to be applied during retreatment with the aim to reduce the resistance of filling materials inside the root canal [12], thus facilitating their removal [2]. Different chemical solvents are available on the market, and they can dissolve obturation materials in different ways [12]. Sometimes, these compounds need to be renewed during the action of the instruments inside the root canal to reach the apical third [2].

The ideal endodontic solvent requires the following properties: high solvent effect, low surface tension, low cytotoxicity, absence of carcinogenic effects, easy to use, quick action, long-life. During a retreatment, when the filling material is unknown, it is very important to have different kind of solvents at disposal, in order to use the most effective one [5,6].

Chloroform is one of the most widely used solvents, because of its efficiency: it's also known as trichloromethane ($CHCl_3$) and it is an organic solvent extremely effective in dissolving the gutta-percha. It is widely used in dental practice for its properties: fast action, simplicity in use, low cost. Chloroform, however, can produce cytotoxic effects and it is potential carcinogenic [13-15]. Since it was identified as a potential carcinogen, the interest has been revived to identify an alternative solvent to soften the gutta-percha during removal procedures.

Aim

The aim of this study is to evaluate and compare the effectiveness of different solvents with ability to dissolve gutta-percha that can be regarded a practicable alternative to chloroform.

Materials and Methods

Specimen preparation

The solvents tested are: group 1: chloroform, group 2: D-limonene (Orange solvent - Ogna Laboratories, Milano, Italy), group 3: mixture of D-limonene and 1,2 dichloropropane, group 4: mixture of D-limonene and turpentine, group 5: turpentine.

Stainless steel ring molds with an internal diameter of 20 mm and a height of 1.5 mm were used for sample preparation. All molds were cleaned in an ultrasound bath for 15 minutes. All molds were weighed 3 times before use (accuracy, +/- 0.0001 g) on a Mettler AE-163 balance (Mettler, Toledo), which was used throughout the experiment. The alpha gutta-percha (Gutta Percha Pellets for Obtura System, Spartan, MO, USA) plasticized using System B Heatsource (Sybron Endo Corporation, CA, USA) at 220°C was placed in molds, previously arranged on a glass plate covered with a Mylar strip. Disks with flat surface and free of air bubbles inside them were obtained placing each specimen above a second plate of glass, also covered by another polyethylene sheet, and exerting a slight pressure. 10 disks of gutta-percha were set up for each solvent, for a total of 50 samples. Each sample of gutta-percha was detached from the molds in steel and was dehydrated under vacuum, using a phosphorus pentoxide (P2O5) dryer for 10 minutes at room temperature. The weight of each sample (initial weighing) was recorded using the same Mettler AE-163 analytical balance (Mettler, Toledo). Each sample of gutta-percha was then inserted in a glass vial with a cap and 1 ml of each tested solvent was added, at room temperature. Each glass vial, immediately closed, was then vigorously stirred for 60 seconds. So the solvent with remaining gutta-percha dissolved in it was filtered using circular paper filters (Whatman n° 1) previously dried at 105°C for 6 hours and cooled in a vacuum desiccator for 10 minutes at room temperature. After filtration process of each sample, the complete evaporation of the solvent was obtained leaving the filter with the related disks of gutta-percha at room temperature for 48 hours. The final weight of each sample was recorded and the net weight of the samples of gutta-percha after the treatment with the solvents was obtained subtracting the initial weight of the filter from the weight of the filter plus the corresponding disk of gutta-percha. Comparing the initial weight and the final weight of the samples the difference in percentage was calculated (amount of gutta-percha not retained by the filter). For each tested solvent the experiment was repeated 10 times on 10 different disks of gutta-percha.

Statistical Analysis

Statistical analysis was performed with Stata 12.0 software (Stata, College Station, TX, USA). Descriptive statistics, including mean standard deviation, median and minimum and maximum values were calculated for all solvents. Data were analyzed by Shapiro Wilk test to assess the normality of the distributions. Non-parametric Kruskal-Wallis analysis of variance test and post-hoc Mann-Whitney post-hoc test were applied to test significant differences among the groups. Statistical difference was set at $P < 0.05$.

Results

The results of solubility test (after 24 hours) are listed in table 1. Shapiro Wilk test revealed that data are not normally distributed. The null hypothesis of the study was rejected. Kruskal Wallis analysis of variance revealed statistically significant differences among groups ($P < 0.05$). The analysis of the results, through Mann Whitney test, showed that chloroform (group 1) has the greatest solubilizing capacity, with a loss of weight, after treatment of disks, equal to a percentage of 4.90% ($P < 0.05$). Significantly lower values were obtained for groups 2 and 3 ($P < 0.05$). Lowest results were obtained for the formulation of group 4 and for the essence of turpentine (group 5): these formulations were not significantly different each others ($P > 0.05$) and appeared not as effective as the others mentioned before: their ability to dissolve gutta-percha was significantly lower ($P < 0.05$) than the other groups. Figure 1 shows percentage weight loss of the samples of gutta-percha: higher values are attributable to higher capacity of the solvent to solubilize the gutta-percha.

Groups	Mean weight differences (g)	Percentage weight differences	Tuckey
Group 1	-0,0615	-4,90%	A
Group 2	-0,0459	-3,21%	B
Group 3	-0,0111	-0,98%	C
Group 4	-0,0045	-0,37%	D
Group 5	-0,0021	-0,18%	D

***Table 1**: Mean weight differences (g) and percentage weight differences for each group.*

Different capital letters indicate significant differences (P < 0.05).

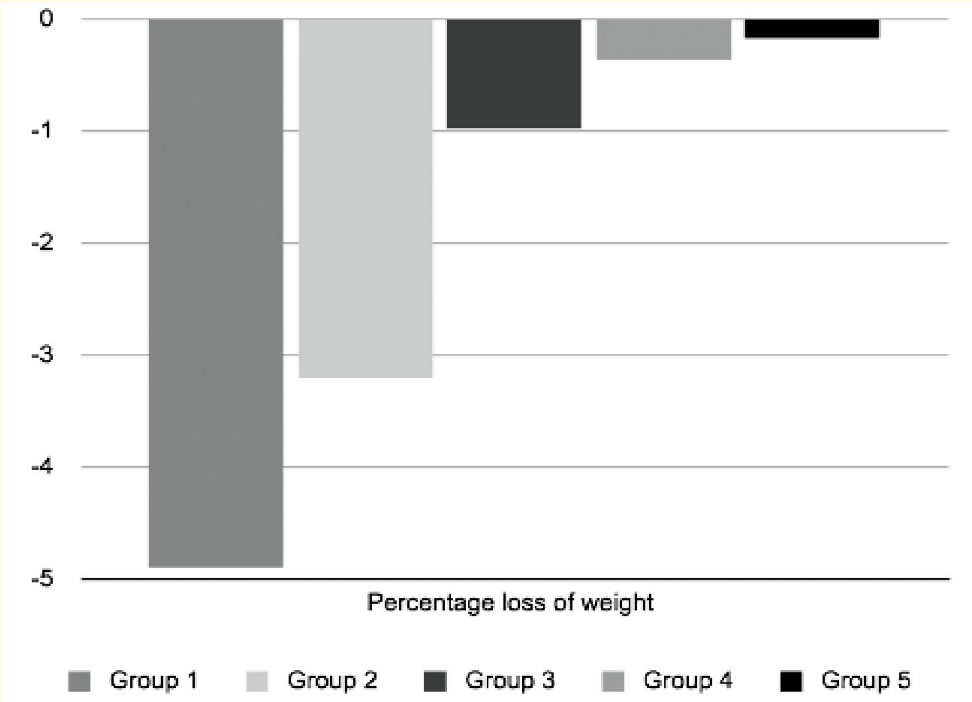

***Figure 1:** Mean percentage weight loss for each group.*

Discussion

The success of non-surgical endodontic retreatment is related to the complete removal of filling materials from the root canal system because the presence of residual filling material in a root canal may result in retreatment failure. Many techniques, instruments and substances have been employed aiming to remove gutta-percha. The use of hand instruments either without or with solvents are emphasized, because the latter decrease the risks of damaging to the tooth structure during the gutta-percha removal [2,3]. Among the chemical solvents, xylene, eucalyptol, orange oil and chloroform have been some of the options more commonly employed [5,6,9]. According to Stabhouz and Friedman [3], the use of solvents is essential for filling material removal within dentinal tubules and ramifications, therefore making easy the biomechanical preparation and the penetration of the irrigant solutions and intracanal medications.

Chloroform is widely used during the retreatment procedures for softening gutta-percha and for facilitating its removal from the root canal. The efficiency, safety and benefit of chloroform as a solvent during endodontic treatment has been proven [16]. However, side effects from exposure to chloroform have also been recorded [17]. Studies have addressed that chloroform is possibly carcinogenic to humans [8,14]. Chloroform is classified as a group 2B carcinogen by the International Agency for Research on Cancer, which points out the materials that lack adequate evidence of carcinogenicity in humans but, there is sufficient evidence of their carcinogenicity in animals [19].

This study tested four different solvents in order to study their capability to dissolve or soften gutta-percha and compared their efficiency to chloroform.

The Orange solvent is traditionally used for the cleansing and removal of cements, pastes and impression materials from instruments, mixing plates, devices, patient skin and tissues, etc., but it's widely indicated as solvent during endodontic retreatments. Orange oil was found to be more biocompatible than eucalyptol, xylol, chloroform and halothane [20] but its efficency is not always proven. Kaplowitz., *et al*. [21] evaluated the ability of essential oils to dissolve gutta-percha, including eucalyptol and orange oil, and compared them to chloroform. The study evaluated the capacity of dissolving sealers using standard ring moulds and gutta percha cone fragments, respectively. The authors found that only chloroform and turpentine oil dissolved gutta-percha completely. On the other side, Hansen., *et a*l. [22], Scelza., *et al*. [23] and Rehman., *et al*. [24] found efficency of Orange solvent similar to chloroform, so they be recommended it as a suitable alternative to this product. This facilitates chemo-mechanical preparation and the irrigating solutions can access to all ramifications of the entire root canal system during retreatment with decreasing of the residual microbial population [25-28]. In spite of all different retreatment strategies, studies showed that it is not possible to obtain root canal walls completely free of debris and residual infection [29].

In this study the Orange Solvent showed discrete effectiveness, higher than other formulations tested. During the execution of an endodontic retreatment, it is important to have different kinds of solvents in order to seek out the most relevant for any particular case: sometimes root canals are sealed with unknown materials [5,6]. It should also be noted that the solvent can be aggressive towards periapical tissues: to prevent harmful and toxic effects against apical cells it must be used great caution approaching the apex [5,9,10].

Conclusions

All tested solvents, even if their components are characterized by a potentially null degree of toxicity, demonstrated small ability in dissolving the gutta-percha, lower than chloroform and Orange solvent. The essence of turpentine, the mixture of D-limonene and turpentine and the mixture of D-limonene and 1,2 dichloropropane had the lowest potential of gutta-percha dissolution.

Within the limitations of this *in vitro* study and based on its results, only the Orange solvent can be considered a viable alternative to chloroform.

Conflict of Interest

The authors deny any conflicts of interest related to this study.

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