Influence of irrigants on the coronal microleakage of laterally condensed gutta-percha root fillings

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Abstract

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Aim To assess *in vitro* coronal microleakage in extracted human teeth after root-canal treatment, using different endodontic irrigants.

Methodology Fifty teeth with single root canals were prepared and filled using the lateral condensation of gutta-percha and Endométhasone sealer. Canal preparation consisted of initial shaping of the coronal two-thirds with Gates-Glidden burs size 2 and 3, followed by preparation of the apical stop and step-back flaring with manual files. Each group ($n = 10$) was irrigated with the following solutions: I – 1% NaOCl, II – 1% NaOCl + 17% EDTA, III – 2% chlorhexidine gel, IV – 2% chlorhexidine gel + 1% NaOCl, and V – distilled water. After root-canal filling, the teeth were incubated at 37 °C for 10 days followed by 10 days immersion in human saliva and an additional 10 days in India ink. The teeth were cleared and maximum dye penetration was determined digitally in millimetres. Statistical analysis was carried out using the Kruskal–Wallis test.

Results Least leakage occurred with 1% NaOCl + 17% EDTA (2.62 mm) and 2% chlorhexidine gel (2.78 mm) ($P > 0.05$). NaOCl (3.51 mm), distilled water (6.10 mm) and 2% chlorhexidine gel + 1% NaOCl (9.36 mm) gave increased leakage with a significant difference compared to NaOCl + 17% EDTA and 2% chlorhexidine gel, and compared to one another ($P < 0.05$).

Conclusions Under the condition of this study, irrigation method during root-canal treatment influenced coronal microleakage. NaOCl + EDTA and chlorhexidine gel allowed better sealing following root filling.

Keywords: chlorhexidine gel, coronal leakage, smear layer, irrigants.

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Introduction

Cleaning and shaping root canals are essential steps in root-canal treatment. Unfortunately, the mechanical action of instruments is unable to reach areas of the root-canal system due to anatomical complexities. As a result, irrigating solutions have an important role in chemo-mechanical preparation (Byström & Sundqvist 1983).

Sodium hypochlorite (NaOCl), a widely used endodontic irrigant, is efficient in dissolving organic tissues as well as eliminating microorganisms. However, NaOCl is cytotoxic when in contact with periapical tissues and is unable to completely remove the smear layer (Ciucchi *et al.* 1989). Formed onto the root-canal surfaces by the action of endodontic instruments, the smear layer consists of pulpal tissue remnants, bacteria, and dentine debris (Ciucchi *et al.* 1989). The smear layer can be forced 1–5 μm into the dentinal tubules, to create a smear plug that reduces dentine permeability up to 78% (Pashley 1984). This layer is acid labile and can be dissolved by fluids with pH between 6.0 and 6.8 (Pashley 1990). Some bacteria may degrade the smear layer via proteolytic enzymes that eliminate the collagen component rather than the hydroxyapatite component (Pashley 1990). Therefore, by acting as a substrate for bacterial growth, the smear layer is susceptible to bacterial penetration.

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The removal of the smear layer provides more efficient disinfection and improves the seal of root fillings due to penetration of sealer into the open dentinal tubules, decreasing microleakage (Behrend *et al.* 1996, Taylor *et al.* 1997).

Two percent chlorhexidine gel used as an endodontic irrigant has been shown to have antimicrobial activity against microorganisms commonly found in endodontic microflora (Ferraz *et al.* 2001). However, it has no effect on dissolving pulpal tissue remnants (Kuruvilla & Kamath 1998). The action of chlorhexidine gel in the removal of organic and inorganic remnants from smeared surfaces is enhanced by its viscosity (Ferraz *et al.* 2001). Moreover, chlorhexidine gel has shown better antimicrobial action against *Enterococcus. faecalis* when compared to its liquid form. One of its advantages is that the biocompatible carbon polymer used as the gel base, Natrosol, is highly water-soluble, being easily removed from the root canal by a final flush with distilled water (Ferraz *et al.* 2001).

When used as an endodontic irrigant, EDTA has an efficient chelating action, dissolving mineralized tissues and promoting smear-free surfaces (Ciucchi *et al.* 1989). According to Yamada *et al.* (1983), to obtain a maximum cleansing effect after instrumentation, it is necessary to use chelating agents (EDTA) followed by a tissue solvent (NaOCl).

The aim of the present study was to assess *in vitro* coronal microleakage in extracted human teeth after root-canal treatment, using different endodontic irrigants.

Materials and methods

Fifty single-rooted maxillary central incisors and mandibular premolars with similar root curvatures of 0–10° (Schneider 1971) were stored in 10% formalin. The teeth were instrumented using a hybrid hand preparation technique (Valdrighi *et al.* 1998). The teeth had their crowns removed and were then divided into 5 groups ($n = 10$) made up of five maxillary central incisors and five mandibular premolars.

Canal preparation

The coronal two-thirds of each canal was prepared initially using files up to size 35. A size 2 Gates-Glidden bur (GG) was then used with gentle force up to this length, followed by a size 3 GG 1 mm shorter. A size 10 file was used to recapitulate the canal 1 mm beyond this length between each file and bur, in order to maintain patency. A size 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) with a rubber stop was introduced carefully into each canal until it was just visible in the apical foramen. This length was noted and 1 mm was subtracted to give the working length of the root. Apical instrumentation commenced with a straight file of the same size as the apical foramen. The instrument was used with a half turn reaming action until the file became loose within the canal. A size 35 or 45 file was used to establish the apical stop for the mandibular and maxillary teeth, respectively. Step-back flaring of the canal was performed using larger files at 1 mm intervals manipulated in a filing action. The file used to prepare the apical stop was used to recapitulate; step-back preparation was completed after the use of three files larger than the file used to prepare the apical stop.

Irrigation

Irrigation was performed using a BD-5 needle coupled to a 5-mL Luer-Loc syringe as follows:

Group I : 1 mL of 1% sodium hypochlorite (1% NaOCl) between each file.

Group II : 1 mL of 1% NaOCl between each file and 5 mL of EDTA for 3 min at the end of the instrumentation.

Group III: 0.5 mL of 2% chlorhexidine gel (Endogel™, Endosupport, Hapetininga, Brazil) between each file.

Group IV: Alternate 1 mL of 1% NaOCl and 0.5 mL of Endogel™ between each file.

GroupV : 1 mL distilled water between each file.

In all groups, a final flush with 5 mL of distilled water was performed to remove debris and the irrigants.

Root canals were filled using standardized gutta-percha points (Tanari, Manaus, Brazil) and Endométhasone sealer (Septodont, Saint-Maur, France) using the lateral condensation technique. Excess gutta-percha was seared off with a hot instrument (Paiva plugger, Dentsply Indústria e Comércio Ltda, Petrópolis, Brazil) 1 mm below the canal orifice. The cervical portion of the warm gutta-percha was vertically condensed firmly using a Paiva No. 2 plugger.

The teeth were then incubated for 10 days at 37 °C to allow the sealer to set. Two layers of nail polish were placed on the entire extent of the root (except on the coronal surface of the gutta-percha), and cyanacrylate was used to seal the foramen before placing the teeth in human saliva at 37 °C for 10 days. The specimens were kept in India ink for 10 days (John Faber Castel, São

Paulo, Brazil) and then washed with tap water to remove excess ink. The nail polish layers were then removed with a scalpel.

The roots were decalcified in flasks containing 30 mL of 5% hydrochloric acid for 48–72 h at 37 °C under constant agitation in an automatic shaker (TE – 420 Tecnal, Piracicaba, Brazil) and then washed with tap water for 12 h to remove remaining acid. After that, the roots were dehydrated in increasing alcohol concentrations and immersed in methyl salicylate until the time for image analysis.

The images were taken with a digital video camera (LG Colour Camera – CCD, Seoul, Korea) connected to a stereomicroscope (Lambda, Hong Kong, China) and analysed with a computer (PC – Intel Pentium 200 MHz, 32 MB RAM, Manaus, Brazil) using ImageLab software version 2.4 (Saftium Informática, São Paulo, Brazil) in order to measure coronal leakage up to the most apical India ink mark . Each tooth was evaluated on the buccal, mesial, lingual and distal surfaces (Fig. 1).

All data were organized in a contingency table and the Kruskal–Wallis test was applied for statistical analysis, with the level of significance set at 5% ($P < 0.05$).

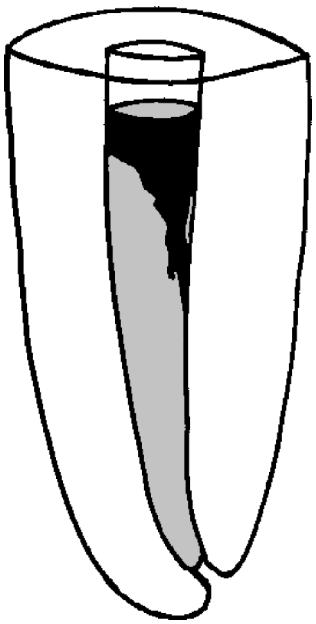

Figure 1 The coronal leakage measurements were taken in millimetres from the top of the gutta-percha obturation to the deepest extent of ink penetration.

Table 1 Coronal linear dye penetration after irrigation regimes and obturation.

Groups	Mean leakage (mm)	SD	Range (mm)
I (1% NaOCl)	3.51[b]	1.31	1.6–7.00
II (1% NaOCl + 17% EDTA)	2.62[a]	0.96	1.26–5.3
III (2% chlorhexidine gel)	2.78[a]	1.41	0.3–5.15
IV (2% chlorhexidine gel + 1% NaOCl)	9.36[d]	1.69	6.00–12.00
V (distilled water)	6.10[c]	2.28	2.88–12.00

Mean followed by the same letter are not significantly different ($P \geq 0.05$).

Results

Data regarding coronal microleakage measured in millimetres are presented in Table 1. The teeth from Group II had the least leakage (mean 2.62 mm) followed by Group III (mean 2.78 mm); there was no significant difference between the two groups. The mean coronal microleakage of teeth from Group I irrigated with 1% NaOCl (mean 3.51 mm) was significantly greater than in Groups II and III ($P < 0.05$). Group IV had the most leakage (mean 9.36 mm) that was significantly deeper ($P < 0.05$) even when compared to the teeth irrigated with distilled water (6.10 mm).

During irrigation of Group IV teeth, the formation of a marked dark-brown precipitate was observed, resulting from the combination of 2% chlorhexidine gel with 1% NaOCl. Even after the final flush with distilled water the precipitate could be observed staining the dentine.

Discussion

The main aim of this study was to evaluate the influence of different irrigation protocols on the sealing of root fillings.

One of the desirable properties of irrigants is smear layer removal (Goldberg & Abramovich 1977). Many authors have demonstrated that canal surfaces without a smear layer permit penetration of filling materials into patent dentinal tubules, increasing the contact surface, improving mechanical retention (White *et al.* 1997) and reducing the possibility of microleakage through the filled canal (Cergneux *et al.* 1987, Behrend *et al.* 1996) independently of the obturation technique (White *et al.* 1984, Saunders & Saunders 1994). An important factor in smear layer removal is the proximity of the irrigation needle to the apical debris. Abou-Rass & Piccinino (1982) showed that the needle must deliver the solution close to the debris to be most effective.

In the present study, the teeth irrigated with 1% NaOCl combined with 17% EDTA and those irrigated with Endogel™ had the least mean coronal microleakage after obturation and exposure to India ink. Previous studies demonstrated that both irrigation methods are highly efficient in smear layer removal (White *et al.* 1984, Ferraz *et al.* 2001), a fact that may have influenced the results.

Previously studied viscous irrigants, including those containing chlorhexidine gluconate, were less soluble substances, leaving residues on the root-canal surfaces which impared final obturation (Tucker *et al.* 1976). The chlorhexidine gel employed in the present study did not produce this effect. The gel base used was Natrosol, a biocompatible carbon polymer (Miyamoto *et al.* 1998) that is a water-soluble substance, and therefore can be easily removed from the root canal with a final flush of distilled water (Ferraz *et al.* 2001). The present results also showed that the chlorhexidine gel (viscous form) did not interfere with the sealing ability of the sealer. Previous studies have shown that it maintains almost all the dentinal tubules open because its viscosity keeps the debris in suspension reducing smear layer formation. Moreover, such viscosity increases the mechanical removal of the organic tissues, which compensates for the inability of the chlorhexidine gel to dissolve them (Ferraz *et al.* 2001). The properties of chlorhexidine gel, such as broad spectrum of antimicrobial activity, substantivity, low toxicity, water solubility and smear layer removal have increased interest in its use as an endodontic irrigant (Gomes *et al.* 2001).

The combination of 1% NaOCl with 2% chlorhexidine gel showed the worst results in the present study. Kuruvilla & Kamath (1998) first suggested this combination to obtain the optimal properties of both irrigants. The authors suggested that chlorhexidine chloride would form, increasing the ionizing capacity of the chlorhexidine molecule and consequently its antimicrobial activity. In that reaction, sodium hypochlorite dissociates into H^+, O^{-2} and Cl^- ions, the chloride group then reacts with the chlorhexidine molecule in the guanine group (NH), resulting in chlorhexidine chloride (N^+Cl^-). However, the authors did not mention the precipitate that forms during this reaction and was frequently observed in the present study. The viscous dark-brown precipitate material stained the dentine and adhered to the root-canal walls. It could not be completely removed from the root canals, probably acting as residual film, damaging the seal of the root-canal filling and favouring coronal microleakage.

Conclusion

This study showed that the irrigating method used during root-canal treatment interferes with coronal microleakage *in vitro*.

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