Surface Tension Comparison of Four Common Root Canal Irrigants and Two New Irrigants Containing Antibiotic

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Abstract

The aim of this study is to compare the surface tension of four common endodontic irrigants: Moltendo EDTA 17%, Cetrexidin, Smear Clear, Sodium hypochlorite 5.25%, with the surface tension of MTAD and Tetraclean. Freshly produced MilliQ water was used as a reference. All measurements were performed following the Wilhelmy plate technique, using a Cahn DCA-322 Dynamic Contact Angle Analyzer at the temperature of 22°C. MilliQ water, sodium hypochlorite 5.25%, and EDTA 17% had the highest surface tension, whereas those of Cetrexedin and Tetraclean has shown the lowest surface tension value. Both new irrigants, MTAD and Tetraclean, are capable of removing the smear layer. Thanks to their low surface tension, increasing the intimate contact of irrigant solutions with the dentinal walls, they may permit deeper penetration. *(J Endod 2006;32:1091–1093)*

Key Words

Antibiotics, cetrexidin, irrigants, MilliQ water, Moltendo EDTA, MTAD, Smear Clear, sodium hypochlorite, surface tension, Tetraclean

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The mechanical debridment of the root canal system fails to completely remove the debris from the root canal walls. So, one or more irrigants must be used for the complete detersion of root canal system (RCS) (1). Therefore, the irrigants must be in contact with the dentin walls and debris. The intimacy of this contact depends on the wettability of the irrigant on solid dentin, and this property of the liquid is strictly correlated to its surface tension (2). The surface tension is defined as "the force between molecules that produces a tendency for the surface area of a liquid to decrease" (3). This force tends to limit the ability of the liquid to penetrate a capillary tube. The irrigants for endodontic use should have very low surface tension. The wettability of the solution governs the capability of its penetration both into the main and lateral canals, and into the dentinal tubules (4–5). By improving the wettability, an irrigant solution could increase its protein solvent capability and enable better antimicrobial activity in uninstrumented areas of RCS (4). Sodium hypochlorite 5.25% is the most common irrigant used in endodontics (6) but it is ineffective in removing smear layer (7) and the use of a second irrigant, like EDTA or citric acid (active against inorganic debris), is required. Moreover, sodium hypochlorite has shown high surface tension, compared with the other irrigants (3), and it is unable to reach bacteria in the depth of the dentinal tubules. Recently, MTAD (8) and Tetraclean (9), two new irrigants based on a mixture of antibiotics, citric acid, and a detergent have been proposed. The two irrigants differ in the concentration of antibiotics (doxycycline 150 mg/5 ml for MTAD and 50 mg/5 ml for Tetraclean) and the kind of detergent (Tween 80 for MTAD, polypropylene glycol for Tetraclean). This study was designed to compare the surface tension of MTAD and Tetraclean with that of the most common endodontic irrigants EDTA 17% and sodium hypochlorite 5.25%.

Materials and Methods

The irrigants tested were: Moltendo EDTA 17% (Molteni Dental, Scandicci (Fi), Italy); Cetrexidin, a mixture of 0.2% Cetrimyde and Chlorhexidine in aqueous base [GABA Vebas, San Giuliano Milanese (Mi), Italy]; sodium hypochlorite 5.25% [Ogna Laboratori Farmaceutici, Muggiò (Mi), Italy]; Tetraclean [Ogna Laboratori Farmaceutici, Muggiò (Mi), Italy]; MTAD (Dentsply Tulsa Dental, Johnson City, TN); and Smear Clear, a mixture of EDTA 17% and Tween 80 (SybronEndo, Orange, CA).

The surface tension of the test liquids was measured following the Wilhelmy plate technique, using a Cahn DCA-322 Dynamic Contact Angle Analyzer [Gibertini Elettronica s.r.l. 20026 Novate (MI), Italy]. Briefly, a glow-discharge cleaned glass slide was immersed in 5 ml of the test liquid in a carefully cleaned glass beaker. The force on the glass slide was continuously recorded by the instrument software as the beaker was raised and withdrawn at the constant speed of 40 micron/s, until at least 1 cm of the glass slide was immersed. The liquid surface tension was calculated by the general equation:

$$F = mg + \gamma_l p\cos\theta + Fb \tag{1}$$

where F is the force measured by the instrument, m the weight of the glass slide, g the gravity constant, p the glass slide perimeter, γ_1 the liquid surface tension, θ the contact angle and Fb the buoyancy force. The last contribution on the right hand side of Eq. 1 can be eliminated by linear extrapolation to zero depth of immersion, whereas the first contribution is zeroed by the instrument software, yielding on rearrangement:

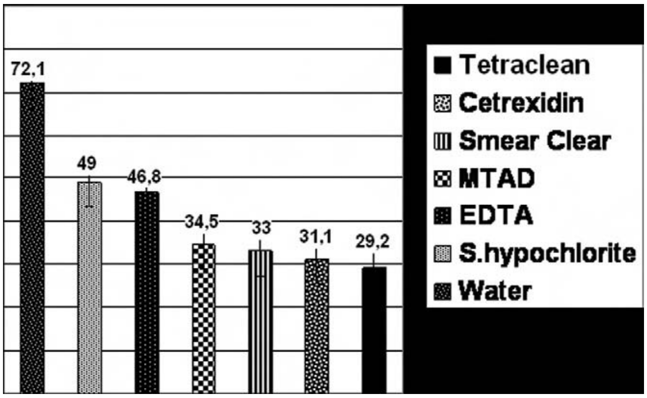

Figure 1. Graphic shows average surface tension values expressed in mJ/m^2 of the six samples examined and distilled water.

$$\gamma_1 = F/p\cos\theta \qquad (2)$$

in case of complete wetting, $\theta = 0$ and e $\cos\theta = 1$, so that:

$$\gamma_1 = F/p \qquad (3)$$

and the liquid surface tension can be obtained by the ratio between the force at zero depth of immersion and the sample perimeter. Measurements were performed at 22°C, using 5 ml of the following test liquids: sodium hypochlorite 5.25%, EDTA 17%, Cetrexidin, MTAD, Tetraclean, and Smear Clear. Freshly produced MilliQ water (distilled water) was used as a reference. MilliQ water was used because even the purest water undergoes contamination on storage, because of interfacial adsorption of ubiquitous hydrocarbons from the atmosphere. As a consequence, the surface tension of water can decrease upon storage below the literature value of about 71 mJ/m^2 (10).

The use of freshly prepared ultrapure water avoids this pitfall. Samples were contained in plastic vials, which were opened immediately before the experiments. The typical accuracy is 0.5 mJ/m^2. For each sample, 15 measurements were performed. Because the lack of homogeneity of variance, tested by Levene test, Kruskal Wallis ANOVA, followed by Mann-Whitney's *U* test, was done to compare results.

Results

Figure 1 shows the mean values of surface tension observed for the different irrigants. Kruskal-Wallis ANOVA revealed significant differences among the different liquids surface tensions ($p < 0.001$), that all was lower than those of distilled water and sodium hypochlorite 5.25% and EDTA 17% (Mann-Whitney *U* test $p < 0.001$). These latter were, respectively, 72.1 mJ/m^2, 49.0 mJ/m^2, and 46.8 mJ/m^2 according with those commonly reported by literature (3, 10).

Tetraclean and Cetrexidin yielded the lowest values (29.2 mJ/m^2 and 31.1 mJ/m^2, respectively). In particular Tetraclean was observed to record surface tension lower than the other irrigants containing antibiotic and/or Ca+ chelants (MTAD and Smear Clean) ($p < 0.01$ and $p < 0.05$, respectively).

Discussion

The failure of endodontic therapy is because of a variety of causes, but the most important is the persistence of bacteria inside the root canal system. Sodium hypochlorite, the most common irrigant used in endodontics, has shown many limitations in its action; e.g. the inability to remove the smear layer and an incomplete action against bacteria because of the resistance of some strains (11, 12). The search for a new irrigant has continued for a long time. A new generation of irrigants is represented by MTAD and Tetraclean, two mixtures based on the synergic action of an antibiotic (antibacterial activity), citric acid (removing the smear layer), and a detergent that should permit a deeper penetration of drugs into the depths of the tubules. These irrigants have shown very high capability in removing the smear layer (8, 9) and in antibacterial activity (9, 13, 14). The surface of the dentin walls treated with these irrigants appears clean and the dentinal tubule orifices are free of smear plugs. A low surface tension should increase the penetration of the mixture into the dentinal tubules, reducing the bacterial contamination of RCS. In our study, the data regarding distilled water, Cetrexidin, EDTA and sodium hypochlorite are similar to those reported by Taşman et al. (3). MTAD has shown a low surface tension (34.5 mJ/m^2), similar to the Cetrexidin one (31.1 mJ/m^2). The lowest surface tension was shown by Tetraclean, only 29.1 mJ/m^2. The surface tension value of Smear Clean (33 mJ/m^2) was very interesting: this irrigant is a mixture of EDTA 17% and a detergent, Tween 80. Its low surface tension and the capability of EDTA, permit removal of the smear layer.

EDTA, however, fails in its antibacterial action, and therefore the combined use of sodium hypochlorite is required (14). Very few studies have addressed the potential effect of the surface tension of irrigating solutions in the overall success of endodontic therapy: some studies tend to indicate that the use of irrigants with low surface tension could reduce the need to remove large quantities of root canal dentin to obtain a debris-free root canal (15). There is no evidence that the reduction in surface tension of endodontic irrigants could improve the clinical reduction of bacteria in the RCS (3); however, the possibility of the penetration of antibiotics into the depths of the tubules opened by citric acid and doxycycline could increase the effect of MTAD and Tetraclean. The reduction in surface tension could improve the intimate contact of irrigants with the dentinal walls of the root canal system.

Tetraclean has shown the lowest value of surface tension and this fact could enable a better adaptation of the mixture to the dentinal walls. Tetraclean and MTAD are able to remove the smear layer and to open the dentinal tubules orifices.

Under such conditions, these irrigants (having a very low surface tension) could bring about a better penetration inside the dentinal tubules, enabling better antibacterial action. Therefore, further investigations regarding the penetration of the irrigant solutions containing antibiotic into the dentinal tubules and bacterial decontamination should be performed to prove the capability of these new irrigants (16).

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