Use of peracetic acid as irrigating agent in Endodontics

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DOI: http://dx.doi.org/10.14436/2358-2545.5.2.056-060.oar

ABSTRACT

The irrigation of the root canal system contributes effectively to appropriate cleanness and antisepsis, thus rendering endodontic treatment more successful. An ideal irrigation protocol was suggested in order to overcome the limitations of commonly used irrigants, in addition to enhancing antisepsis. This protocol recommends the use of sodium hypochlorite during biomechanical preparation, followed by the use of a chelating agent, and again the use of an agent with antimicrobial action. However, it demands considerable clinical time. An alternative to reducing that time would be the use of a final irrigating agent contemplating both chelating and antimicrobial actions. Thus, it has been suggested that peracetic acid (PAA) be used as a substitute for EDTA for final irrigation, since this substance has shown good antimicrobial potential associated with chelating capacity. Some studies have been conducted in order to analyze the effectiveness of its use as an irrigating solution in Endodontics. This literature review aims to present to clinicians and specialists in Endodontics the properties of this irrigating solution by providing relevant information on its effectiveness and feasibility in the endodontic practice.

Keywords: Peracetic acid. Irrigating solution. Chelating agent.

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How to cite this article: Fernandes SL, Tartari T, Bronzato JD, Bramante CM, Vivan RR, Andrade FB, Duarte MAH. Use of peracetic acid as irrigating agent in Endodontics. Dental Press Endod. 2015 May-Aug;5(2):56-60.
DOI: http://dx.doi.org/10.14436/2358-2545.5.2.056-060.oar

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Submitted: May 19, 2015. Revised and accepted: June 26, 2015.

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Introduction

Successful endodontic treatment depends on the cleaning and shaping of root canals along with avoidance of recontamination after obturation.[20,33] It is during biomechanical preparation and intracanal medication that the removal of microorganisms, responsible to contaminate the root canal, as well as inflamed and necrotic tissues, which can serve as substrates for microbial proliferation, occurs.[12] However, due to the complex anatomy of root canals, most of root canal system walls remain untouched by endodontic instruments.[27] This makes the irrigation procedure very important due to the chemical action of cleaning and antisepsis, and also the physical action that allows irrigating solutions to reach areas of difficult access.[19,28] It is therefore critical that irrigating solutions have the ability to act over organic and inorganic matter, in addition to having antimicrobial activity, so as to assist in obtaining adequate cleaning and antisepsis.[5,14,38]

Among irrigating solutions, the most commonly used in Endodontics are sodium hypochlorite (NaOCl) and ethylenediaminetetraacetic acid (EDTA).[38] However, these irrigants as well as others, have their limitations. NaOCl, mainly used for biomechanical preparation, acts over organic matter and microorganisms, but does not act over inorganic matter.[25,38] While EDTA, used after instrumentation, acts over inorganic matter, promoting removal of dentin debris and smear layer, but is incapable of dissolving organic matter.[17,36]

In order to overcome the limitations of irrigants and enhance disinfection, the use of NaOCl has been recommended as an ideal irrigation protocol during biomechanical preparation, followed by a chelating agent, such as EDTA, in order to remove the smear layer, and finally again NaOCl or another antimicrobial agent.[38] Nevertheless, this protocol can enormously increase clinical chair time.

One way to simplify and reduce clinical chair time would be to use, throughout biomechanical preparation, a chelating agent that when mixed or in contact with NaOCl does not interfere in its properties. The use of a chelating agent with a strong antimicrobial action, used as a final irrigant, would also be proposed. A promising substance to be used as a chelating agent with antimicrobial action is peracetic acid (PAA).[17]

Despite being widely used in Endodontics in Eastern Europe in the 1980s, PAA has only recently been suggested as an auxiliary chemical solution with the potential to replace EDTA in the final irrigation procedure after biomechanical preparation. PAA is a peroxygen that, at concentrations lower than 0.5%, presents with sporicidal, bactericidal, fungicidal and virucidal action, even in the presence of proteins.[16] When it is used, PAA is decomposed into safe by-products, such as acetic acid and oxygen. The fact that acetic acid is released or found in PAA solutions highlights the possibility of this substance being used after instrumentation as a final irrigant to dissolve the smear layer and contribute to the antisepsis of the root canal system.[17]

PAA can be clinically advantageous due to its ability to leverage antisepsis of the root canal system and confirm the removal of inorganic part. This literature review aims to present to clinicians and specialists in Endodontics the properties of this irrigating solution by providing relevant information on its effectiveness and feasibility in endodontic practice.

Antimicrobial activity

The antimicrobial potential of PAA was a crucial factor in the proposition of its use in Endodontics as a final irrigant replacing EDTA. This substance has fast broad-spectrum antimicrobial action, being able to inactivate gram-positive and gram-negative bacteria, fungi and yeasts within 5 minutes or less.[29] The explanation for this property is in its oxidizing action which leads to denaturing of proteins, cell membrane rupture, sulfhydryl oxidation, and the formation of sulfur bonds in proteins, enzymes and other metabolites along with microbial death.[4]

Different concentrations of PAA have been tested *in vitro* to verify the most ideal one to obtain a satisfactory antimicrobial effect. In a study using *Enterococcus faecalis* suspension, it was found that 1% PAA reduced bacterial counts by 86% after 3 minutes, and completely eliminated *E. faecalis* after 10 minutes, showing effective action against *E. faecalis*, although its action was slower than 2.5% NaOCl and 2% CHX.[11] The antimicrobial action of 1% PAA was also analyzed in single-rooted teeth contaminated with *E. faecalis,* and results showed that the groups with 1% PAA, 2.5% NaOCl, and 2% chlorhexidine had bacterial counts

lower than the other groups.[9] A similar conclusion was found when using the mesial roots of mandibular molars also contaminated with *E. faecalis*, in which final irrigation with 1% PAA showed comparable antimicrobial results to conventional irrigation using 17% EDTA followed by 2.5 % NaOCl, which reinforces its use in order to reduce the ideal irrigation protocol.[4]

When the action of 2% PAA was evaluated in 5-day biofilm, the solution presented a percentage of dead cells similar to chlorhexidine, and significantly lower when compared to NaOCl and NaOCl + HEBP mixture. In consideration of the decrease in the total biovolume, results with PAA continued lower than that yielded with NaOCl and mixture of NaOCl + HEBP, but were higher than the control group and the chlorhexidine group.[1] In biofilms created *in situ* over dentin, 4% PAA solution proved as efficient as 2.5% to 5.25% NaOCl solution to remove and kill biofilm.[23]

During filling of the root canal system, it is important to prevent micro-organisms from being brought into the root canal system. Because of its high antimicrobial potential, PAA was also tested in disinfection of gutta-percha cones infected *in vitro* with *Escherichia coli*, *Staphylococcus aureus*, *Streptococcus mutans*, *Bacillus subtilis*, and *Candida albicans*.[31] The authors observed that exposure of the cones for only 1 minute to 2% PAA was effective against all biofilms tested. These results were corroborated by a further study that showed that PAA disinfection worked better than 3% NaOCl and similar to 2% chlorhexidine on both gutta-percha and resilon cones contaminated with *Bacillus subtilis* and *Enterococcus faecalis*.[34]

Organic matter dissolution

Proper cleaning of root canals is one of the main requirements of endodontic treatment, since the removal of tissue and microbial debris prevent the tooth from becoming a source of infection.[38] It was noted that when intracanal medication was not used, there was an increased number of microorganisms, and this was attributed to remaining tissues that can provide ideal conditions for bacterial multiplication.[7] However, unlike NaOCl which dissolves organic matter, PAA showed no dissolving properties for soft tissues dissolution, such as pulp tissue; thus, PAA poses some limitations when used as a main irrigant during biomechanical preparations.[21]

Removal of smear layer

The removal of smear layer achieved during instrumentation of root canal walls is an essential condition for the best antimicrobial effectiveness of an irrigating solution in the dentinal tubules,[37] in addition to improving the sealing ability of obturation.[32] PAA has a favorable antimicrobial action that proves effective at removing smear layer from the root canal walls. 2.25% PAA was found to be as effective as EDTA in the final irrigation.[17] Another study comparing 0.5% and 2.25% PAA to 17% EDTA showed that after 60 seconds of dentin exposure there was a similar action of removing smear layer among all irrigants.[6] Studies assessing the antimicrobial action and studies assessing the removal of smear layer reveal some disagreement regarding the parameters of concentration, temperature, pH and volume of the solution.

Impacts on dentinal structure

Studies have shown that in addition to the removal of microorganisms, dissolution of organic and inorganic matter, irrigants are able to damage the dentin microstructure, leading to alterations in the relation of organic/inorganic surface matter.[8,40] The type and intensity of these changes in the proportion of dentinal components depend on the irrigating solution used and can influence the quality of adhesion of sealers and cements used for cementing intracanal posts.[24,26]

Due to its acidity, PAA showed to be capable of removing calcium from the root canal walls in the same proportion as EDTA, a strong chelating agent, but more alkaline. Furthermore, 2.25% PAA promoted akin erosion to dentin walls similar to that caused by 17% EDTA.[17] More recently, a study revealed that irrigation protocols that use PAA after using NaOCl provide a great loss of calcium, and lead to a significant reduction in dentin microhardness.[35] In another investigation, this irrigant also proved to have the power to reduce significantly the levels of phosphorus, magnesium, potassium, sodium, and sulfur in the dentin structure.[3] Analysis of these results together demonstrates that PAA is a chelating agent that should be used with caution so that no excessive demineralization happens on the dentin surface, which could interfere in the following stages of the endodontic treatment.

Impacts on the adhesion of materials to dentin

Evaluation of the influence of irrigants over the adhesion of sealers, root-end filling materials, and cements for post cementation is of utmost importance and has been the subject of several studies, since these materials will ensure the stability and success of endodontic treatment and allow the tooth to remain in function. However, only one research was found evaluating the influence of 1% PAA on the adhesion of MTA in drilling sites artificially created in dentin, with no decrease in the adhesiveness of MTA being identified.[22]

Removal of calcium hydroxide

The use of intracanal medication is recommended to enhance the antisepsis of contaminated root canals, and calcium hydroxide (CH) is a widely used product due to its excellent properties.[39] However, studies have proved that calcium hydroxide residues left on root canal walls may influence adhesion to dentin[10] and the penetration of cement into dentinal tubules.[2,18] It has also been suggested that calcium hydroxide residues can chemically react, adversely affecting the properties of sealers.[13] Due to these factors, research was conducted to evaluate the efficacy of different irrigating solutions in the removal of CH, in which it was observed that 1% PAA solution showed a better potential for removal of CH from the root canal walls than 0.5% PAA, 17% EDTA and combined use of 2.5% NaOCI with 17% EDTA.[30]

Biocompatibility

One of the major disadvantages of PAA is its strong and unpleasant smell. In spite of this, irrigants containing PAA were used throughout Eastern Europe and in the former German Democratic Republic to sanitize the root canal systems without any report of adverse events.[15] In a recent investigation, it was noted that PAA can be as caustic as NaOCl at the same concentration.[17] However, more studies are needed to verify the biocompatibility of this substance in its various concentrations with the periapical tissues.

Protocol

There is still no defined protocol for the use of PAA as irrigant in endodontic treatment, and more research is needed in order to assess the real impacts of this irrigating solution on dentin structure, adhesion of materials to root canal and biocompatibility with periapical tissues. However, based on this literature review, it is clear that PAA is a promising agent for final irrigation. Results point to its use in concentrations as low as 0.5% and 1%, which retain their antimicrobial activity, and for only 60 seconds, which was shown to be long enough to promote removal of smear layer without causing significant changes in the dentinal structure. Nevertheless, it is possible to indicate 2% PAA for gutta-percha disinfection, as it achieved better results than NaOCl.

Conclusion

From the data obtained in the current literature review, it was found that peracetic acid (PAA) is presented as a promising solution to be used in the final irrigation of root canal systems, considering it has excellent antimicrobial action and capacity to remove smear layer. Notwithstanding, more studies are suggested for clinical recommendation.

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