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The efficacy of ultrasonic irrigation in endodontics: A review

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Abstract
Debridement of the root canal system is essential for endodontic success. Irrigation is a vital part of root canal debridement. It is impossible to shape and clean the root canal completely because of the intricate nature of root canal anatomy. The triad of biomechanical preparation, pulp space sterilization and three-dimensional obturation is the hallmark of endodontic success. Complete disinfection of the pulp space cannot be achieved with most sophisticated instrumentation techniques. The role of irrigants in obtaining this goal cannot be underestimated. Optimal irrigation is based on the combined use of two or several irrigating solutions, in a specific sequence. However, currently there is no universally accepted standard irrigation technique. The aim of this article is to review armamentarium and various irrigants in endodontic practice.

Keywords: Endo rinse, endovac, navitip, ruddle brush, vapour lock effect

Introduction

Ultrasonic irrigation can be performed with or without simultaneous ultrasonic instrumentation. Effective irrigant delivery and agitation are prerequisites to promote root canal disinfection and debris removal and improve successful endodontic treatment. Several different systems of mechanical activation of irrigants to improve endodontic disinfection were analysed: manual agitation with gutta-percha cones, endodontic instruments or special brushes, vibrating systems activated by low-speed hand-pieces or by sonic or subsonic energy, use of ultrasonic or laser energy to mechanically activate the irrigants and apical negative pressure irrigation systems. The ultrasonic activation of root canal irrigants and of sodium hypochlorite in particular still remains the gold standard to which all other systems of mechanical agitation analyzed in this article were compared. From this overview, it is evident that the use of different irrigation systems can provide several advantages in the clinical endodontic outcome and that integration of new technologies, coupled with enhanced techniques and materials. Existing literature reveals that ultrasonic irrigation may have a very positive effect on chemical, biological and physical debridement of the root canal system as investigated in many *in vitro* studies. The purpose of this review article was to summarize and discuss the available information concerning ultrasonic irrigation in endodontics. This article presents an overview of ultrasonic irrigation methods and their debridement efficacy. In this paper the relevant literature on passive ultrasonic irrigation is reviewed. Information from original scientific papers or reviews listed in MEDLINE and Cochrane were included in the review. The use of ultrasound in the irrigation procedure results in improved canal cleanliness, better irrigant transfer to the canal system, soft tissue debridement, and removal of smear layers and bacteria. There are many *in vitro* studies, but there is a need to standardize protocols, and correlate the clinical efficacy of ultrasonic devices with improved treatment outcomes. Understanding the basis of ultrasonic irrigation is fundamental for clinicians and researchers to improve the design and use of ultrasonic irrigation.

Sodium Hypochlorite

Sodium hypochlorite (NaOCl) is the most popular irrigating solution. NaOCl ionizes in water into Na1 and the hypochlorite ion, OCl-, establishing equilibrium with hypochlorous acid (HOCl). At acidic and neutral pH, chlorine exists predominantly as HOCl, whereas at high pH of 9 ad abve.

Hypochlorous acid is responsible for the antibacterial activity; the OCl- ion is less effective than the undissolved HOCl. Hypochloric acid disrupts several vital functions of the microbial cell, resulting in cell death (Barrette *et al.*, 1989; McKenna and Davies, 1988) [3]. Hypochlorite preparations are sporicidal and virucidal and show far greater tissue dissolving effects on necrotic than on vital tissues. These features prompted the use of aqueous sodium hypochlorite in endodontics as the main irrigant as early as 1920.

There has been much controversy over the concentration of hypochlorite solutions to be used in endodontics. The antibacterial effectiveness and tissue dissolution capacity of aqueous hypochlorite is a function of its concentration, and so is its toxicity (Zehnder, 2006) [6]. It appears that the majority of American practitioners use ―full strength‖ 5.25% sodium hypochlorite as it is sold in the form of house hold bleach leading to several adverse reactions like irritation and decrease in flexural strength of dentin. Also decrease in microbiota was also not significantly altered with this high concentration. It must be realized that during irrigation, fresh hypochlorite consistently reaches the canal system, and concentration of the solution may thus not play a decisive role (Zehnder, 2006) [6]. One of the methods to improve the efficacy of sodium hypochlorite was to use heated solution. This improves their immediate tissue-dissolution capacity. Furthermore, heated hypochlorite solutions remove organic debris from dentin shavings more efficiently than unheated counterparts. The weaknesses of NaOCl include the unpleasant taste, toxicity, and its inability to remove the smear layer by itself, as it dissolves only organic material. The limited antimicrobial effectiveness of NaOCl *in vivo* is also disappointing. The poorer *in vivo* performance compared with *in vitro* is probably caused by problems in penetration to the most peripheral parts of the root-canal system such as fins, anastomoses, apical canal, lateral canals, and dentin canals. Also, the presence of inactivating substances such as exudate from the periapical area, pulp tissue, dentin collagen, and microbial biomass counteract the effectiveness of NaOCl (Haapasalo *et al.*, 2000) [7]. Recently, it has been shown by *in vitro* studies that long-term exposure of dentin to a high concentration sodium hypochlorite can have a detrimental effect on dentin elasticity and flexural strength (Although there are no clinical data on this phenomenon, it raises the question of whether hypochlorite in some situations may increase the risk of vertical root fracture. In summary, sodium hypochlorite is the most important irrigating solution and the only one capable of dissolving organic tissue, including biofilm and the organic part of thesmear layer. It should be used throughout the instrumentation phase. However, use of hypochlorite as the final rinse following EDTA rapidly produces severe erosion of the canal-wall dentin and should probably be avoided (Niu *et al.*, 2002) [10].

Chlorhexidine

Chlorhexidine was developed in the late 1940s in the research laboratories of Imperial Chemical Industries Ltd. (Macclesfield, England). The original salts were chlorhexidine acetate and hydrochloride, both of which are relatively poorly soluble in water. Hence, they have been replaced by chlorhexidine digluconate. Chlorhexidine is a potent antiseptic, which is widely used for chemical plaque control in the oral cavity. Aqueous solutions of 0.1 to 0.2% are recommended for that purpose, while 2% is the concentration of root canal irrigating solutions usually found in the endodontic literature. It is commonly held that chlorhexidine would be less caustic than sodium hypochlorite. However, that is not necessarily the case. A 2% chlorhexidine solution is irritating to the skin. As with sodium hypochlorite, heating a chlorhexidine irrigant of lesser concentration could increase its local efficacy in the root canal system while keeping the systemic toxicity low. Despite its usefulness as a final irrigant, chlorhexidine cannot be advocated as the main irrigant in standard endodontic cases, because (a) chlorhexidine is unable to dissolve necrotic tissue remnants, and (b) chlorhexidine is less effective on Gram-negative than on Gram-positive bacteria.

EDTA

Although sodium hypochlorite appears to be the most desirable single endodontic irrigant, it cannot dissolve inorganic dentin particles and thus prevent the formation of a smear layer during instrumentation (). Demineralizing agents such as ethylenediamine tetraacetic acid (EDTA) and citric acid have therefore been recommended as adjuvants in root canal therapy These are highly biocompatible and are commonly used in personal care products. Although citric acid appears to be slightly more potent at similar concentration than EDTA, both agents show high efficiency in removing the smear layer (Zehnder, 2006) [6]. In addition to their cleaning ability, chelators may detach biofilms adhering to root canal walls. An alternating irrigating regimen of NaOCl and EDTA may be more efficient in reducing bacterial loads in root canal systems than NaOCl alone (Zehnder, 2006) [6]. Antiseptics such as quaternary ammonium compounds (EDTAC) or tetracycline antibiotics (MTAD) have been added to EDTA and citric acid irrigants, respectively, to increase their antimicrobial capacity. The clinical value of this, however, is questionable. Generally speaking, the use of antibiotics instead of biocides such as hypochlorite or chlorhexidine appears unwarranted, as the former were developed for systemic use rather than local wound debridement and have a far narrower spectrum than the latter. Both citric acid and EDTA immediately reduce the available chlorine in solution, rendering the sodium hypochlorite irrigant ineffective on bacteria and necrotic tissue.

Hence, citric acid or EDTA should never be mixed with sodium hypochlorite (Zehnder, 2006) [6].

Need for newer root canal irrigants

All the irrigation solutions at our disposable have their share of limitations and the search for an ideal root canal irrigant continues with the development of newer materials and methods. Newer root canal irrigants in the horizon are as follows: (1) MTAD, (2) Electrochemically activated solutions, (3) Photon-activated disinfection, (4) Herbal irrigants. The article reviews the advantages and shortcomings of these newer irrigating agents and their potential role in endodontic irrigation in near future.

MTAD

Bio Pure MTAD (Dentsply, Tulsa, OK) is a mixture of a tetracycline isomer, an acetic acid, and Tween 80 detergent (MTAD)—was designed to be used as a final root canal rinse before obturation (Torabinejad *et al.*, 2003) [11]. Tetracycline has many unique properties of low pH and thus can act as a calcium chelator and cause enamel and root surface demineralization (Grande et al). Its surface demineralization of dentin is comparable to that seen using citric acid (Grande *et al*). In addition, it has been shown that it is a substantive medication (becomes absorbed and gradually released from tooth structures such as dentin and cementum. Finally, studies have shown that tetracycline significantly enhances healing after surgical periodontal therapy. Manufacturer instructions for using this irrigant were flooding the root canal with

Summary
Irrigation has a key role in successful endodontic treatment. Although hypochlorite is the most important irrigating solution, no single irrigant can accomplish all the tasks required by irrigation. Detailed understanding of the mode of action of various solutions is important for optimal irrigation. New developments such as CFD and mechanical devices will help to advance safe and effective irrigation.

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