New Technologies to improve root canal disinfection

By Drs Gianluca Plotino, Nicola M. Grande & Prof. Gianluca Gambarini, Italy

Introduction

The major causative role of microorganisms in the pathogenesis of pulp and root canal infections has been demonstrated. The main aim of endodontic therapy is to disinfect the root canal system, which requires the elimination of microorganisms and their biofilm components and the prevention of reinfection during and after treatment. This goal is pursued through chemical-mechanical debridement, for which mechanical systems are used with irrigating solutions.

Standard endodontic irrigation protocol

Sodium hypochlorite (NaOCl) is the main irrigant used, owing to its antibacterial properties and its high concentrations (5-6%) which have greater tissue-dissolving properties. However, the greater the concentration, the more severe the potential reaction if some of the irrigant is inadvertently forced into the periapical region. To reduce this risk, the use of specially designed endodontic files and an irrigation technique without pressure is recommended.1

EDTA

The main disadvantage of NaOCl is its cytotoxicity, causing irritation to the tissues and potential perforation of the root canal walls. EDTA is used during the instrumentation phase to increase its time of action within the canal as much as possible without it being chemically altered by the presence of other substances. Its cytotoxicity is minimized and limited to the tip of the instrument used, while the effect of acoustic streaming is more significant.2 Ultrasonic activation creates bubbles of posi-

3 The effectiveness of this system in some cases may limit its use in root canal treatment, but makes it an excellent additional technique to enhance the cleaning and disinfection of the root canal system at the end of the preparation.5, 10 The concept of continuous irrigation was developed in the past with the use of mechanical instruments for sonic and mechanical debridement that could concurrently clean through the continuous re-lease of irrigant. These techniques were then abandoned for various reasons related to the poor quality of the irrigation fluid.6, 7

Sonic activation

Sonic activation has been shown to be an effective method for disinfecting the root canals.15 Sonic activation has been demonstrated to improve the intracanal disinfection of the root canal system significantly.21 Sonic activation has been attributed to the effective absorption of the laser light by NaOCl. This leads to the vaporization of the irrigant and to the formation of vapor bubbles, which expand and collapse with secondary cavitation effects. When it is activated in a limited volume of liquid, the high absorption

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Mechanical activation of endodontic irrigants, and in particular NaOCl, is recommended.2 EDTA is a mixture of inorganic and organic debris from the root canal walls.3

Ultrasonic activation of NaOCl

The use of ultrasound is advantageous and at the end of the root canal preparation phase is an indispensable step in improving endodontic disinfection. The range of frequencies used in the ultrasonic unit is between 25 and 40 kHz. The effectiveness of ultrasonic irrigation is determined by the power of the instrument, the use of a piezoelectric transducer, and the type and manipulations carried out during irrigation.22 The use of ultrasound in endodontic canal preparation has been shown to improve the cleaning and disinfection of the root canal system.23, 24 The use of ultrasound during irrigation is determined by the presence of air bubbles in the canal space, but does not improve the final cleaning.25 Another similar technique moves vertically a gutta- percha cone to working length with the canal filled with irrigant. Even if this method, however, has not been found to improve the intracanal cleaning,26 it is useful in those cases in which the canal is filled with air bubbles. The use of ultrasonic activation has been considered to be advantageous.26–28 Other similar systems use smooth plastic tips or plastic cones that are passive in the canal. The use of mechanical agitation techniques and the removal effect of organic and inorganic debris from the root canal walls.7

Manual agitation techniques

The simplest technique of mechanical activation of irrigants is manual agitation, which can be performed with different systems. The easiest way to achieve this effect is to move vertically an enameled file itself. This system has shown excellent results in terms of periodontal collagen and mechanical debridement, for which ultrasound in irrigation is determined by the type and manipulations carried out during irrigation.22 The use of ultrasound during irrigation is determined by the presence of air bubbles in the canal space, but does not improve the final cleaning.25 Another similar technique moves vertically a gutta-percha cone to working length with the canal filled with irrigant. Even if this method, however, has not been found to improve the intracanal cleaning,26 it is useful in those cases in which the canal is filled with air bubbles. The use of ultrasonic activation has been considered to be advantageous.26–28 Other similar systems use smooth plastic tips or plastic cones that are passive in the canal. The use of mechanical agitation techniques and the removal effect of organic and inorganic debris from the root canal walls.7

Chlorhexidine

A final rinse of 2% chlorhexidine (CHX) after the use of NaOCl (to dissolve the organic component) and EDTA (to dissolve the inorganic component) has been proposed to ensure good disinfection, owing to its broad spectrum of action and its property of substantivity.1 However, the use of CHX is hindered by the interaction between NaOCl and CHX, which tends to cause precipitation and the impaired tooth and precipitates that may potentially contaminate this area. For this reason, CHX should not be used in conjunction with or immediately after NaOCl.29

Activation systems

Mechanical instrumentation alone can reduce the number of microorganisms present within the root canal system even without the use of irrigants and intracanal dressings.30, 31 However, these procedures are not sufficient to improve the intracanal disinfection of the root canal system significantly.32, 33 Irrigation systems without the aid of mechanical activation are able to reduce the intracanal bacterial infec-

Continuous irrigation during instrumentation

Recently, a new system for root canal preparation has been introduced to the market. This system uses a particular instrument with an ultrasonic activation of the irrigant that concomitantly carves or with a surface with lateral plastic extensions, that have dimensions appropriate to achieve the working length. The ultrasound is activated by the action of the instrument, whereas the irrigation system is passive.22 During ultrasonic activation, the irrigant is released into the canal and activated by the ultrasound in the root canal space, as ultrasonic activation greatly increases the flow of liquid and improves both the solvent action of the irrigant and the removal of organic and inorganic debris from the root canal walls.3

Ultrasonic activation of NaOCl

30–60 s for each canal, with three cycles of 10–20 s (always using new irrigation solutions). The irrigation of NaOCl is used during the instrumentation phase to increase its time of action within the canal as much as possible without it being chemically altered by the presence of other substances. Its effectiveness is enhanced in the majority of cases similar to ultrasonic activation techniques.27–29 From a clinical perspective, positive pressure systems can be effectively integrated with ultrasonic irrigation techniques because they act by different mechanisms. They can operate in synergy with the objective to obtain cleaner canals, especially in the apical third and the most inaccessible areas.

Laser activation

The interaction between the laser and the irrigant in the root canal is a new area of interest in the field of endodontic disinfection. This con-cept is based on the lasers-activated irrigation (LAI) and photon-initiated photocoustic streaming (PIPS) technology.34, 36, 37 The mechanism of this interaction has been attributed to the effective absorption of the laser light by NaOCl. This leads to the vaporization of the irrigant and to the formation of vapor bubbles, which expand and collapse with secondary cavitation effects. When it is activated in a limited volume of liquid, the high absorption

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of the laser in NaOCl combined with the short pulse duration employed (10 μs) determines a photomechanical phenomenon. A study showed that there was no difference in bacterial reduction achieved by NaOCl alone.32 Another study investigated the capability of LAD to remove a bacterial biofilm created in vitro on the canal walls.33 This study found that it did not completely remove the film from the apical third of the root canal and infected dentinal tubules. However, the laser-activated disinfection generated a higher number of samples with negative bacterial cultures and a lower number of bacteria in the apical third was a promising result regarding the effectiveness of the technique, and has been confirmed by a more recent study.34

Additional disinfection systems

In addition to the above-mentioned systems that were able to activate the endodontic irrigants and to improve the disinfection process, other noninstrumentation techniques may further disinfect the root canal system, particularly during the last phases of the treatment. These techniques have the potential to eliminate microorganisms. For this purpose, different substances and technologies have been investigated over time with different results.

Photocatalytic disinfection

A novel concept recently introduced in endodontics in photocatalytic disinfection. This technique is based on the illumination of certain molecules (photocatalysts, PS) that have the ability to convert to the disinfection of the bacteria. The PS is activated with a specific wavelength of light, which causes an alteration of the bacterial cell wall on which the PS is bound, resulting in a change of the biofilm structure and a subsequent increase in its permeability associated with the loss of its functions. The PS is then transmitted through the root canal and into the oral cavity.43,44 The endodontic disinfection is performed in two different steps: application of the PS and laser disinfection.45

Laser

One of the main disadvantages of the current endodontic irrigants is their inability to reach the entire root canal.46 In addition, the selectivity of the PS is reduced when used along with the laser, making it difficult to achieve a complete disinfection.47

In the endodontic field, several systems of lasers have been used to improve root canal disinfection: the diode laser, carbon dioxide laser, IR YAG laser and Nd YAG laser. The bactericidal action of the laser depends on the characteristics of its wavelength and energy, and in many cases it is due to the thermal effect induced by the laser on the alteration of the cell wall. The laser disinfection is usually performed in two or three sessions, each session separated by a few days.48,49

Laser disinfection is the most effective of the above techniques and results in a significant reduction of bacteria and biofilm adherent to the root canal and not necessarily laterally to the root canal.50,51 Laser disinfection has been shown to be effective in improving the outcomes of endodontic treatment.52

Bioactive glass

Recently, bioactive glass or bioactive glass ceramics have been subjects of many research studies in endodontics, disinfection owing to their antibacterial properties,53 and conflicting results have been obtained.54

Natural plant extracts

A current trend is the use of natural plant extracts, taking advantage of the antibacterial activity of polyphenolic molecules generally used for storing food. These compounds have been found to have potent antibacterial activity, but several deman- rate significant ability to reduce the formation of biofilms, with conflicting results.55

Ozone

Ozone is an unstable and energetic form of oxygen that rapidly dissociates in water, creating reactive forms of oxygen that can oxidize cells. It has been suggested that ozone may have an antimicrobial effect without inducing the development of bacterial resistance.56,57 This ma-

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