Acta Scientific MEDICAL SCIENCES (ISSN: 2582-0931)

Volume 7 Issue 9 September 2023

Review Article

Modern Methods of Decontamination of the Endodontic System

Elena Zabrac[1], Ioana Suciu[2]*, Dana Bodnar[3], Bogdan Dimitriu[2], Monica Voiculeanu[2], Ruxandra Ioana Bartok[4] and Mihaela Chirila[2]

[1]PhD Student at University of Medicine and Pharmacy "Carol Davila" Bucharest, Romania

[2]Department of Endodontics, University of Medicine and Pharmacy "Carol Davila" Bucharest, Romania

[3]Department of Operative Dentistry, University of Medicine and Pharmacy "Carol Davila" Bucharest, Romania

[4]Department of Esthetic Dentistry, University of Medicine and Pharmacy "Carol Davila" Bucharest, Romania

***Corresponding Author:** Ioana Suciu, Department of Endodontics, University of Medicine and Pharmacy "Carol Davila" Bucharest, Romania.

DOI: 10.31080/ASMS.2023.07.1653

Received: July 28, 2023

Published: August 08, 2023

Abstract

This review article offers various aspects of the use of disinfection methods that are actually used in endodontics. So, along conventional root canal decontamination methods, namely sodium hypochlorite and EDTA irrigation, adjuvant methods can be used to improve the quality of the endodontic system disinfection. In this respect, the dental laser facilitates guiding the irrigant into difficult-to-reach areas for instruments (isthmus, dentin canaliculi, apical delta, the cross-section extension of the oval canal, lateral canals). Ozone therapy, as well as nanoparticle therapy can be added as an adjuvant to the classical therapeutic scheme.

Keywords: Erbium Laser; Disinfection Endodontics; NaOCl; EDTA

Introduction

Understanding the morphological aspects of the endodontic space of permanent teeth is the key to success in diagnosing and applying a working protocol appropriate to the pulp and periapical pathology.

Due to the unpredictable configuration of the endodontic space, the access of desinfectants is hindered under the circumstances where the root canal is colonised with complex endodontic biofilm; the purpose of endodontic therapy is to remove the infected pulp tissue and prevent inflammation of the periapical tissue.

The microflora in the infected root canal is varied, with the predominance of anaerobic bacteria (70-100% of the cases), enterococcus Faecalis [1], which can form complex biofilms, can survive under conditions of nutrient and oxygen deprivation. Enterococcus faecalis is a gram positive anaerobic bacteria, which is usually found in the oral cavity and in the digestive tract. In many studies, its prevalence in biofilm is high in secondary infections, with predilection in retreatments, more than in primary infections [1-3]. *E. Faecalis* is not always responsible for the failure of endodontic treatment. Its ability to form complex biofilms on the root canal walls makes the endodontic system disinfection difficult, as it is one of the most resistant pathogens [4].

Mechanical treatment of root canals uses endodontic instruments in combination with chemical substances for enlargement, disinfection of the endodontic system and lubrication which reduces the risk of blockage and fracture of the instrument in the root canal.

During mechanical and chemical preparation stages, it is essential to use irrigants following the usual protocol (frequency, quantity and concentration). The main role of the irrigant is to minimize microorganisms, pulpal/necrotic tissue, and also has an impact on the infected dentin substrate acting as a chemical decontamination agents on organic substrate [5].

After the mechanical and chemical treatment, the final form of the root canal emerges to facilitate its three-dimensional filling.

In terms of the conventional decontamination of root canals, sodium hypochlorite and EDTA are the most important.

Sodium hypochlorite 2.5-6% is the irrigant of choice used in endodontics. NaOCl removes debris and produces the solubilisation of organic tissue, having a bactericidal action when directed in difficult-to-reach areas for instruments, to lead the irrigant solution when is activated ultrasonical into the lateral canaliculi. It is used alternatively with EDTA, having a complementary effect [5-10]. It is a good tissue solvent with antimicrobial effects and low clinical cytotoxicity. The effect of sodium hypochlorite is improved by the frequency and temperature at which the irrigation is performed, by the renewal of the solution, by ultrasonic or laser activation. The surface tension of the solution has an effect on the penetration in the dentinal canaliculi and accessory canals [11].

EDTA facilitates instrumentation, acting on the inorganic substrate and on the remaining dentinal detritus. It has little known cytotoxicity, it causes micro retentions, dentinal erosions after extended contact. In case of residues, it requires removal irrigation. It has a weak antibacterial effect, it might creates disaggregation of the biofilm, facilitating the diffusion of antimicrobial substances into the biofilm [12].

Pressure injection of sodium hypochlorite into the root canal causes inflammatory symptoms: pain, soft tissue vasodilation, periapical hemorrhage and, in some cases, the development of secondary infections and paraesthesia [13]. Sodium hypochlorite must be handled with great care during root canal treatments, to avoid such accidents.

In a conclusion, it can be said that NaOCl is the standard irrigation medium for root canals; during the preparation, EDTA removes the dentinal detritus.

Various studies have shown that EDTA and citric acid can remove the smear layer to allow the penetration of the disinfectant solution and of the endodontic sealant into the dentinal canaliculi [14]. Goldman., *et al*. [15] and Yamada., *et al*. [16] have proven that using EDTA 17% together with NaOCl leads to a better decontamination of the endodontic system. EDTA is well known for its reaction with calcium ions in the dentin, resulting the formation of soluble calcium chelates. The use of root canal irrigants, NaOCl together with EDTA 17%, during mechanical canal treatment reduces the microbial amount [17].

Following root canal preparation, a smear layer is formed [18], which, when analysed under the electronic microscope, it consists of dentin, odontoblast fragments, pulp tissue and biofilm [19]. This smear layer hampers the disinfection of the root canal.

The innovative technology of the Erbium laser is that it controls bleeding and reduces the use of anesthetics during works. The pulse power applied repeatedly to the hard dental tissue can reach 12-15 W, being similar to that of the conventional drilling technique, 10-12 W. Thus, the laser becomes an effective alternative in minimally invasive therapy.

Unlike short-wavelength lasers, they can also be used in dental caries treatment.

Laser therapy in endodontics

The bacterial biofilm in apical periodontitis is complex and diversified. Complete eradication of microorganisms from the endodontic system is not possible, but the main goal in endodontic treatment is to reduce the load of microorganisms so as not to cause inflammation. The morphological complexity of the endodontic system is another aspect that can make it difficult to prepare and disinfect the root canal.

Enterococcus Faecalis is a bacterium that proves to be difficult to remove even after a root canal is enlarged and disinfected. It is found in failed endodontic treatments and in root canals with persistent infection [20], not currently considered to be responsible for the failure of endodontic treatments by himself, only in correlation with the biofilm.

Laser-assisted therapy is an adjuvant method in the disinfection of the root system, through the two effects produced at the dentinal level: photothermal, due to direct irradiation of microorganisms and photoacoustic through the cavitation phenomenon.

The Er-YAG laser can be used at a subablative power level to stimulate the irrigation of root canals. The subablative energy of the Er-YAG laser (20 mJ, 15 Hz) and of diodes induces the phenomenon of cavitation, consisting in the expansion of bubbles and the dissolution of the irrigant, followed by the creation of hydrodynamic pressure [21-23]. The Erbium laser has high absorption in water and NaOCl, favouring the evaporation effect. The vapours, thus formed, after 100-200 μs, will undergo implosion, being the second cavitation effect [24]. The radial and longitudinal pressure is sufficient for the movement of the irrigant in the dentinal canaliculi and in the collateral canaliculi for debris removal and disinfection of the root canal [25].

The photodynamic activation of the irrigant leads to an increase of the solution temperature, which entails a removal of debris from the dentinal walls and an increase in the irrigant efficiency [25].

Laser use in endodontics leads to unblocking the dentinal tubes through the evaporation effect of the smear layer. At the same time, the risks of preheating and ablation, as well as the extrusion of the irrigant are eliminated.

Another advantage of using lasers in endodontics is that its light can penetrate up to >1000 microns in the dentin and the bacteria colonise the dental tubules to the same depth [25].

In case of photodynamic activation with lasers, the canal must be prepared in the apical third up to min 25/30 ISO, taper 04 or 06. NaOCl is always used as an activation medium. Activation is performed with the help of Er: YAG 04/17 or 06/17 mm laser tips, at a power of 0.5 W, 40 mJ – 10 Hz, for 20-60 seconds.

In 2012, a protocol was suggested to use lasers during the irrigation of root canals [26], consisting of three PIPS activation cycles (photon induced photoacoustic streaming) of sodium hypochlorite for 30 seconds, followed by three cycles of 30 seconds each, using the conventional method of irrigation. Then, the PIPS laser with serum is used for 30 seconds, followed by the third EDTA irrigant, which is used to irrigate for 30 seconds with the PIPS. As the last step, PIPS and serum is used (30 sec) to remove EDTA [26].

In a study by Schoop., *et al*. [27], the bactericidal effect of the Nd:YAG lasers, diodes, Er: YAG and Er, Cr:YAG was analysed. The Er:YAG laser achieved the best result, given that the study was carried out on small dentine sections of 6x2x1 mm [25].

There are studies that concluded that laser-assisted therapy and the phenomenon of PIPS remove the detritus better in the apical third than the passive ultrasonic activation of the irrigant [28-30].

Arslan., *et al*. [30] proved that PIPS is much more effective than EndoActivator.

At a microscopic level, the Erbium laser (PIPS) improves the irrigant penetration over a larger area of the dentin tubules compared to passive ultrasonic irrigation, EndoActivator and the conventional method [31,32].

The complex system of the root canal is free from debris and disinfected more efficiently compared to conventional endodontic techniques, the evolution after treatment having a better prognosis.

But also, the intracanal infection and the persistance of residual bacteria in the endodontic system might lead to root canal treatment failure that sometimes can be accompanied by endodontic pain. In this respect, it seems that diode lasers have a great penetration in the endodontic system, acting on the biofilm inside the dentinal tubules.

Recently, lasers can reduce the pre- and posttreatment pain in connection with endodontic therapy, inducing the photobiomodulation effect on the periapical tissue. With the advanced technology of lasers and the implementation of new lasers based therapies, like photobiomodulation therapy, antimicrobial photodinamic therapy, have also been used to reduce and control of pain and reminalization of periapical lesions [33].

Conclusion

It can be said that: endodontic technology has evolved to benefit patients and clinicians, easing the stages of endodontic treatment. Rotary preparation of root canals shortens the working times, but removal of debris from dentinal walls is performed only on the main canaliculus, with restricted access to the dentinal canaliculi. The main purpose of root canal preparation is to decontaminate the entire endodontic system and sodium hypochlorite plays the most important role in this respect.

The success of an endodontic treatment is due to the decontamination and sealing of the root canal system, this being achieved by using the auxiliary means of root canal disinfection. The dental laser is a successful option, to be used as an adjuvant method of decontamination, having the advantage of removing the smear layer from dentinal canaliculi and allowing the irrigant to penetrate a larger area of the dentin. This is a promising method in endodontics due to its photodynamic and photoacoustic effects on the remaining dentinal detritus.

Laser evolution from Nd-YAG to Er-YAG (PIPS) has made it safer and easier to use in endodontics.

Bibliography

1. Gomes BP., *et al*. "Microorganisms from canals of root filled teeth with periapical lesions". *International Endodontic Journal* 36 (2003): 1-11.
2. Rocas IN., *et al*. "Association of enterococcus Faecalis with different forms of periradicular diseases". *Journal of Endodontics* 30 (2004): 315-320.
3. Singh H. "Microbiology of endodontic infections". *Journal of Dentistry and Oral Hygiene* 2 (2016): 1-4.
4. Murad CF., *et al*. "Antimicrobial activity of sodium sodium hypoclorite, chlorhexine, and MTAD against Enterococcus faecalis biofilm on biofilm on human dentine". *Revista Brasileira de Odontologia* 9 (2012): 143-150.
5. Domenico Ricucci., *et al*. "Endodontology: An integrated biological and clinical view". (2003): 193.
6. Estrela C., *et al*. "Mechanism of action of sodium hypochlorite". *Brazilian Dental Journal* 13 (2002): 113-117.
7. Zahed Mohammadi. "Sodium hypochlorite in endodontics: an update review". *International Dental Journal* 58 (2008): 329-341.
8. Cohen S., *et al*. "Vertical root fractures: clinical and radiographic diagnosis". *Journal of the American Dental Association* 134 (2003): 434-441.
9. Cohen S., *et al*. "A demographic analysis of vertical root fractures". *Journal of Endodontics* 21 (1995): 337-339.
10. Siqueira JF Jr., *et al*. "Evaluation of the effectiveness of sodium hypochlorite used with three irrigation methods in the elimination of Enterococcus faecalis from the root canal, *in vitro*". *International Endodontic Journal* 1997 30 (1997): 279-282.
11. Ioana Suciu and Bogdan Dimitriu. "Infectia sistemului endodontic". Editura Universitara Carol Davila (2016).
12. Sen BH., *et al*. "The smear layer: A phenomenon in root canal therapy". *International Endodontic Journal* 28 (1995): 141-145.
13. Hauman CH and Love RM. "Biocompatibility of dental materials used in contemporary endodontic therapy: a review. Part 1. Intracanal drugs and substances". *International Endodontic Journal* 36 (2003): 75-85.
14. A Khademi., *et al*. "The Effect of EDTA and Citric Acid on Smear Layer Removal of Mesial Canals of First Mandibular Molars, A Scanning Electron Microscopic Study". *Journal of Research in Medical Sciences* 2 (2004): 80-88.
15. Goldman M., *et al*. "The efficacy of several endodontic irrigating solutions: A scanning electron microscopic study". *Journal of Endodontics* 8 (1982): 487-492.
16. Yamada Rs., *et al*. "A scanning electron microscopic comparison of a high volume final flash with several irrigating solutions". *Journal of Endodontics* 9 (1983): 137-142.
17. Senna RA., *et al*. "The effect of EDTA on the antibacterial activity of sodium hypochlorite". *General Dentistry* 66 (2018): 74-78.
18. Bagchi S. "Telemedicine in rural India". *PLoS Medicine* 3 (2006): 297-299.
19. Kirshner M. "The role of information technology and informatics research in the dentist-patient relationship". *Advances in Dental Research* 17 (2003): 77-81.

20. Love RM. “Enterococcus faecalis - a mechanism of its role in endodontic failure”. *International Endodontic Journal* 34 (2001): 399-405.

21. de Groot SD., *et al*. “Laser-activated irrigation within root canals: cleaning efficacy and flow visualization”. *International Endodontic Journal* 42 (2009): 1077-1083.

22. Blanken J., *et al*. “Laser induced explosive vapor and cavitation resulting in effective irrigation of the root canal. Part 1: a visualization study”. *Lasers in Surgery and Medicine* 41 (2009): 514-519.

23. De Moor RJ., *et al*. “Laser induced explosive vapor and cavitation resulting in effective irrigation of the root canal. Part 2: evaluation of the efficacy”. *Lasers in Surgery and Medicine* 41 (2009): 520-523.

24. Olivi G and DiVito E. “Photoacoustic endodontics using PIPS: experimental background and clinical protocol”. *Journal of Laser Health Acad.* 2012.1 (2012): 22-25.

25. Dr Gregori M Kurtzman. Laser-enhanced endodontic treatment”. laser-dentar.com (2021).

26. Koch JD., *et al*. “Irrigant flow during photon-induced photoacoustic streaming (PIPS) using Particle Image Velocimetry (PIV)”. *Clinical Oral Investigations* 20.2 (2021): 381-386.

27. A Moritz., *et al*. “Oral Laser Application”. *Lasers in Dentistry* (2003).

28. de Groot SD., *et al*. “Laser-activated irrigation within root canals: Cleaning efficacy and flow visualization”. *International Endodontic Journal* 42.12 (2009): 1077-1083.

29. De Moor RJ., *et al*. “Efficacy of ultrasonic versus laser-activated irrigation to remove artificially placed dentin debris plugs”. *Journal of Endodontics* 36.9 (2010): 1580-1583.

30. Arslan H., *et al*. “Effect of photon-initiated photoacoustic streaming on removal of apically placed dentinal debris”. *International Endodontic Journal* 47.11 (2014): 1072-1077.

31. Akcay M., *et al*. “Dentinal tubule penetration of AH Plus, iRoot SP, MTA fillapex, and guttaflow bioseal root canal sealers after different final irrigation procedures: A confocal microscopic study”. *Lasers in Surgery and Medicine* 48.1 (2016): 70-76.

32. Louis E Chavez de Paz., *et al*. “The Root canal Biofilm”. Springer (2015).

33. “Current Application and Future Directions of Lasers in Narrative Review”. *Bioengineering* 10 (2023): 226.