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Mini Review

Irrigation: The Key for Success in Modern Endodontics?

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Abstract

The ultimate goal of endodontic therapy is the removal of bacteria from the root canal space, but the anatomical complexities make it often difficult. Many new high-performing instruments have been introduced to shape the root canal and to make each therapy easy and safe. However, the role of irrigating solution is essential to guarantee the success of root canal treatment: so new devices and strategies have been currently developed to improve the efficiency of chemical solutions, in order to facilitate the dissolution of organic and inorganic tissues and to disinfect the whole canal system. The activation and the heating of irrigating solution play a central role in promoting an effective cleaning of the endodontic anatomy: that's why "three-dimensional" cleaning is considered a primary concept in modern endodontics. Only the 3D cleaning of root canals can guarantee the 3D sealing and the long-term success of endodontic therapy.

Keywords: *Irrigating Solutions; 3D Cleaning; Disinfection; Sodium Hypochlorite; EDTA; Heating; Ultrasonic*

Abbreviations

NaOCl: Sodium Hypochlorite; EDTA: Ethylenediaminetetraacetic Acid

Introduction

Endodontic therapy is based on cleaning, shaping and sealing the root canal system [1] in order to achieve the complete dissolution of residual pulpal tissue, the elimination of bacteria from the root canal space and the prevention of recontamination after the treatment [2-5]. The anatomy of the root canals is complex (Figure 1 and 2) and the instruments can shape only the main canals, but effective cleaning relies on irrigating solutions: the use of chemical solution with bacteriostatic or bactericidal capabilities and tissue-dissolving attributes is recommended in order to facilitate the debridement and the cleaning of the root canal space. Irrigating solutions are considered to be essential for successful endodontic treatment [6-10]. Mechanical preparation cannot effectively eliminate bacteria from the root canal system [11,12]. The objectives of irrigation are both mechanical and biologic [13]: the mechanical purpose involves flushing out debris, lubricating the canal and dissolving organic and inorganic tissue; the biologic function is related to their antimicrobial effect. Sodium hypochlorite (NaOCl) is still the most preferred irrigating solution, thanks to its numerous advantages: it is an excellent antibacterial agent, capable of dissolving necrotic tissue, vital pulp tissue and the organic components of dentin and biofilm; in addition, it is inexpensive, with a long shelf life, and it is easily available [1,14]. But, even if it is a highly effective antimicrobial agent, it does not remove the smear layer from the dentin walls and for this reason the ethylenediaminetetraacetic acid EDTA is strongly recommended for its ability to che-

late hard tissue and its decalcifying action [15-21]. NaOCl shows antiseptic properties due to the formation of hypochlorous acid and the subsequent release of chlorine, which is a very active bactericide [1]. Free chlorine in NaOCl dissolves necrotic tissue by breaking down proteins into amino acids; to obtain this effect concentrations ranging from 0.5% to 5.25% have been recommended [1]. Manipulations that enhance the efficacy of NaOCl include warming the solution [21]: increasing the temperature from 22°C to 45°C has been shown to strengthen both tissue dissolution ability and antibacterial action [22,23]. Endodontic failure may occur in cases of persistent bacteria in the root canal system [24]. Endodontic pathogens have developed a variety of strategies to survive in adverse conditions. They may invade dentinal tubules and persist in superficial layers of dentin adjacent to the canal lumen [25,26] and they may organize as biofilms, complex sessile communities performing numerous adaptive changes in behavior that increase their resistance to a variety of chemotherapeutic agents compared with their planktonic counterparts [27]. Since the persistence of a bacterial burden at the time of obturation appears strictly related to the failure of the treatment [28,29], there is a strong need to improve the efficacy of disinfecting procedures in endodontic therapy.

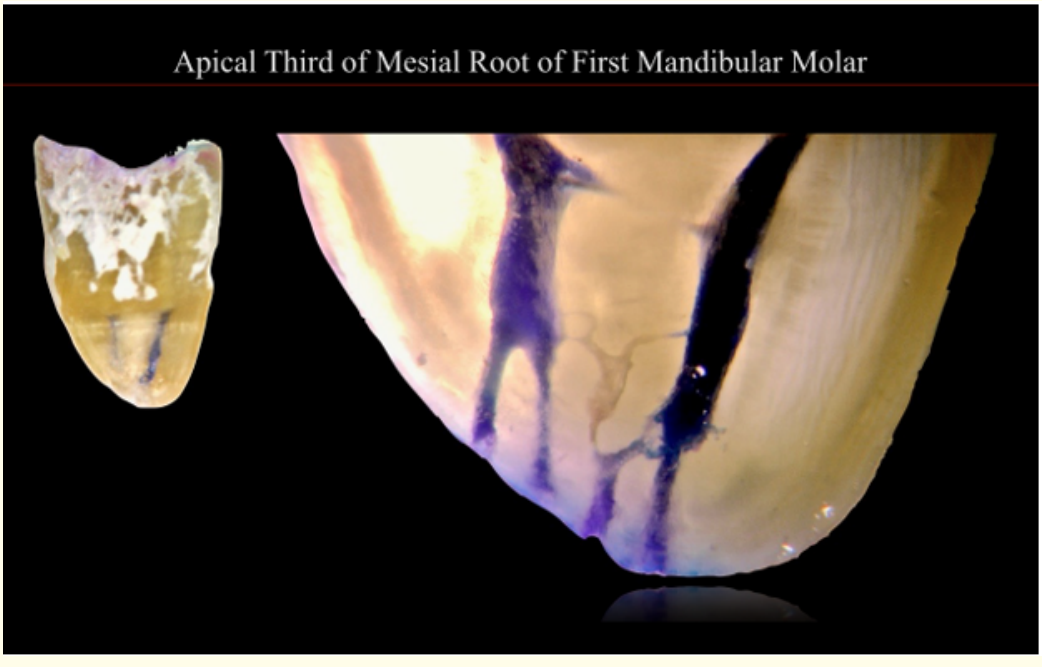

Figure 1: *Complex apical third of the mesial root of a first mandibular molar, impossible to shape only with files (courtesy of Dr. Alfredo Iandolo, Italy).*

5% NaOCl has been recommended as an irrigating solution in the treatment of infected root canals because of its well-known bactericidal action; it is effective in aiding the mechanical flushing of debris from root canals, dissolves organic matter and has a broad spectrum of antimicrobial activity [30]. NaOCl effectively eliminates microbes from root canals [7-11]. No consensus has been arrived at yet regarding the correct concentration for use in endodontics: the right concentration is a compromise between its antibacterial activity and its cytotoxicity. Bystrom and Sundqvist in 1983 [15] suggested use of 0.5% NaOCl in order to minimize cytotoxicity; but some doubt has been cast on the effectiveness of 0.5% NaOCl [19]. The disinfecting efficiency depends on the concentration, which ranges from 0.5% to 5.25%. Radcliffe., *et al.* [30] evaluated the in vitro antimicrobial activity of varying concentrations of NaOCl versus different microorganisms. They observed that *E. faecalis,* the most resistant to NaOCl, reduced its CFU/ml to zero when exposed to 0.5% NaOCl for 30 minutes, to 1.0% NaOCl for 10 minutes, to 2.5% NaOCl for 5 minutes or to 5.25% NaOCl for 2 minutes. Similar results were obtained by Gomes., *et al*. [31]: they showed that 0.5% NaOCl took 30 minutes to destroy bacterial cells of *E. faecalis*, while 5.25% NaOCl requires less than 30s to obtain the same results; so they concluded that 5.25% is the ideal and the most effective concentration.

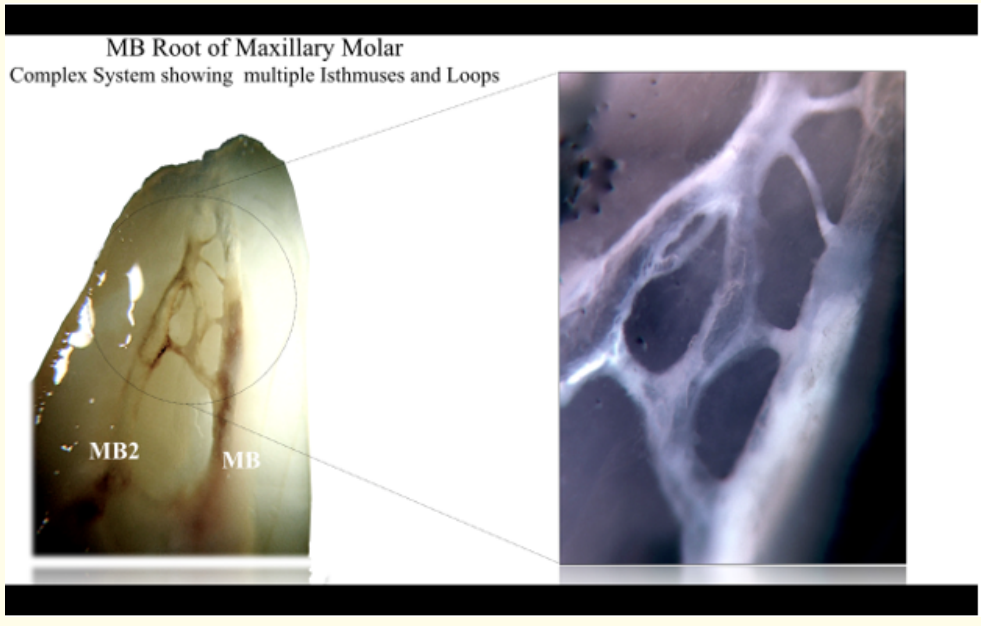

Figure 2: *Complex endodontic anatomy of the mesio buccal root of a maxillary molar: isthmuses and loops can be reached only by irrigating solutions (courtesy of Dr. Alfredo Iandolo, Italy).*

Other than conventional irrigation, additional techniques for endodontic disinfection have been proposed and tested; recently several devices for endodontic irrigation have been introduced in order to improve the efficiency of irrigating solutions.

Techniques for the activation of irrigating solutions

Current Literature suggests various techniques to improve the effectiveness of NaOCl as irrigating solution.

Actually, the passive ultrasonic activation represent the most used technique: it consists on the vibration of irrigating solutions by dedicated ultrasonic tips (25 - 40 KHz). This technique allows, through a phenomenon called acoustic streaming, an intense stirring of the irrigant, as a better antibacterial activity and a greater dissolution of the tissues [7]. Some sonic or subsonic devices are available for the activation of irrigating solutions, with lower frequencies than sonic devices. For this reason they are less efficient in promoting the canal cleaning [11]. Mechanical activation can also obtained with different types of files, for example using files or micro brushes mounted on micro-motor handpieces: Literature shows some encouraging results using these techniques, even if devices and instruments are always not developed for this aim and not easy to dispose of [12,18]. Manual dynamic activation is a simple and cheap technique based on up and down movements of gutta-percha cones inside the root canal up to the working length: it's a very simple technique but not comparable to previous techniques in terms of effectiveness [18,20].

Preheating of NaOCl solution up to 45 - 50°C is a well-known system to increase its efficiency [21-23]. Woodmansey in 2005 has shown that hypochlorite at boiling temperature is able to disgregate the pulp tissue at speed 210 times higher than compared to the solution at room temperature: for this reason, the author proposed the intracanal heating of NaOCl using an heat source device like the System-B by Analytic Endodontics (Orange, CA, USA) [32]. So, further studies about intracanal heating of NaOCl were conducted and the technique was perfected, in order to validate that intracanal heating at 180°C for few seconds drastically increases the efficiency and doesn't produce adverse effects in surrounding tissues like periodontal ligament and bone [33-35].

Laser assisted irrigation is a satisfactory technique for detersion of the endodontic space, but some limits are related to the high cost of the equipment and to the risks of apical extrusion of the irrigant [36]. Negative pressure systems for irrigation allow a good cleaning in the apical third compared to conventional positive pressure systems, with the additional advantage of no apical extrusion of the solution [37]. The only limitations of this technique are the price of the system and the requirement for preparation of the apical diameter at least equal to 0.35 ISO, not always achievable especially in narrow and curved long canals [37].

Presentation of a combined 3D cleaning technique

In daily endodontic practice, not depending on which instrumentation technique used, a simple and predictable irrigation protocol has to be used, in order to obtain the best cleaning as possible of the root canals. The association of NaOCl and EDTA universally represent the gold standard in modern endodontics [1], but the effectiveness of irrigating solution can be enhanced to reach a complete 3D cleaning of the complex canals anatomy.

Sodium hypochlorite has a boiling temperature included between 96°C and 120°C, depending on its concentration, and the higher is the temperature the more is chlorine released. According to Woodmansey principles [32], the technique has been revised and improved by Simeone and Iandolo [33,34], reducing the temperature of the heat carrier from 200°C to 180°C: the boiling point is quickly reached at 180°C and maintained for few seconds, with no evaporation of the solution, in order to avoid overheating of the root and to guarantee the safety for the periodontal ligament too. A small 30.04 heat carrier is passively used 3 mm to the working length for few seconds (no more than 5 - 6 seconds). During activation, the heat carrier makes short excursions of 2 mm up and down in order to shake the irrigant. At the end of heating, irrigating solution is activated for 20 - 30 seconds by an ultrasonic passive tip. After ultrasonic activation, NaOCl is replaced with fresh solution and the cycle is repeated for 5 times, until the root canal space is ready for drying and final obturation.

Figures 3-6 show post-operative X-rays of difficult clinical cases managed by intracanal heating of NaOCl using Elements Free Unit device for downpacking (Sybron Endo Kerr, Orange, CA, USA) set at 180° and ultrasonic activation using EndoUltra (MicroMega, Besancon, France) with 20.02 titanium tip: not depending on which file system used, lateral canals, isthmuses, loops and each anatomical variation can be adequately reached by activated irrigating solutions. For this reason, 3D obturation of root canals is the certain outcome of the 3D cleaning.

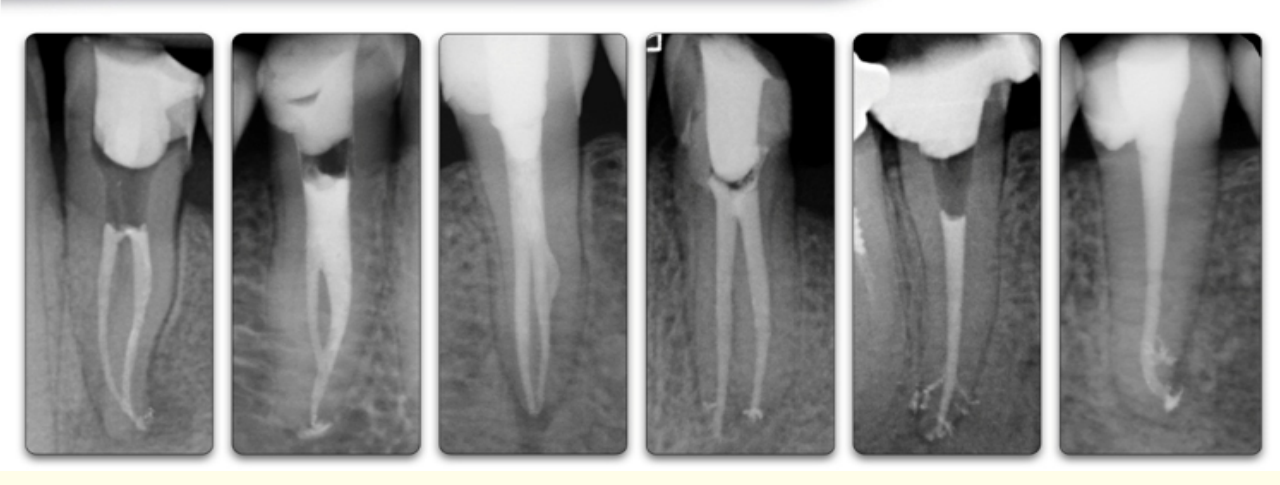

Figure 3: *Post-operative X-rays of some complex mandibular premolars with difficult anatomies.*

Figure 4: *Post-operative X-rays of some complex maxillary premolars with difficult anatomies.*

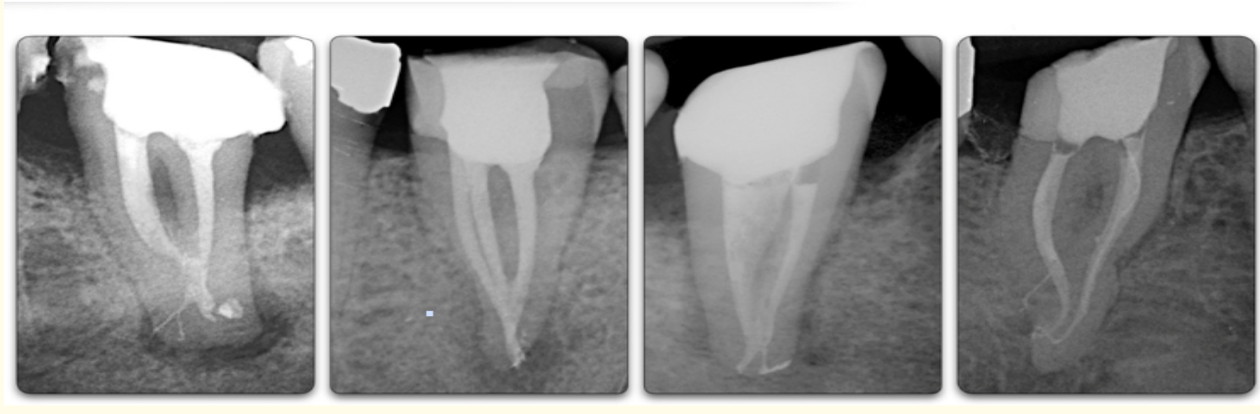

Figure 5: *Post-operative X-rays of some complex maxillary molars with difficult anatomies*

Figure 6: *Post-operative X-rays of some complex maxillary molars with difficult anatomies.*

Conclusion

After some years of clinical practice and preliminary published researches, this combined technique with intracanal heating of NaOCl associated to ultrasonic activation seems to be an effective, reliable and simple solution for successful irrigation and 3D cleaning of endodontic space. Further studies and clinical follow-up are obviously recommended.

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Conflict of Interest

There are no conflicts of interest.

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