Ministry of Higher Education

and Scientific Research

University of Maysan

College of Dentistry

Effect of irrigation on longterm prognosis in endodontic with periapical lesion

A Project Submitted to The College of Dentistry, University of Misan,Department of conservative and Endodontics in Partial Fulfillment for the Bachelor of Dentistry conservative Endodonti

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بسم الله الرحمن الرحيم

صدق الله العظيم

DEDICATION

For the pillar of the mill and the light of the earth, our Iman is the awaited proof, may God speed up his appearance

For the sake of the land on which we lived, our dear homeland and our valiant army, we dedicate this research to our quest with gratitude

ACKNOWLEDGEMENTS

First of all

Praise be to God for what He has bestowed upon Him, and to Him is gratitude for what He has inspired

After that, we would like to extend our sincere thanks to the ,Deanship of the Faculty of Dentistry, Maysan University represented by the Dean, the heads of departments and the teaching staff for the dedication that was offered to get us to this stage

We would also like to extend our sincere thanks to our for his effective role and , ***Dr. ALI SALIH*** ,honorable professor his constant perseverance in providing us with all the useful and valuable information throughout this journey

Last but not least, we extend our heartfelt thanks and gratitude to everyone who contributed to the realization and completion of this project

List of contact

Introduction

Successful root canal therapy is always based on the combination of proper instrumentation, irrigation, and obturation of the root canal.1 The goal of endodontic therapy is to remove all vital or necrotic tissue, microorganisms, and microbial byproducts from the root canal system.2 This is under constant irrigation canal achieved by shaping the root to remove the inflamed and necrotic tissue, microbes, biofilms and other debris from the root canal space.1 There is no single irrigating solution that can alone cover all of the functions required from an irrigant.1 Optimal irrigation is based on the in a proper ,solutions combined use of 2 or several irrigating sequence, to predictably obtain the goals of safe and effective irrigation.1 An Ideal irrigant should be nontoxic, dissolve necrotic and vital pulp tissue, kill microorganisms, serve as lubricant, remove the smear layer and mechanically flushes Apart from chemical nature out the debris from root canal.1 of the irrigants, the mode, depth and volume of delivery of irrigants used are critical factors that determine the efficacy of the irrigants.1 Therefore, a suitable irrigant and irrigant delivery system are essential for efficient irrigation and the success of endodontic treatment.3 The ability to deliver irrigants to the root-canal terminus in a safe manner without causing harm to the patient is as important as the efficacy of those irrigants.3 Traditionally, irrigation has been performed with a plastic syringe and an open-ended needle into the canal space. An increasing number of novel needle-tip designs and equipment are emerging in an effort to better address the challenges of irrigation.1 nowadays modern methods and techniques have been proposed and developed to make root canal irrigants more effective in removing debris and bacteria from the root canal system. The use of these methods results in better canal cleanliness when compared with that of conventional syringe needle irrigation.4

History

The first listed literature about the need for frequent irrigation of the root canal was advocated by Taft. He recommended the use of a deodorizing agent such as sodium chloride. [5] The early literature describes various methods for obtaining a clean canal using a variety of flushing agents and medications. Schreir (1893) introduced potassium and sodium metals into canals for removal of necrotic pulp. [6] A 20-5% aqueous solution of sulfuric acid applied to a cotton pledget and sealed into the root canal for 24–48 hours was introduced by Callahan 1894)). A saturated solution of bicarbonate soda was then introduced into the root canals, thereby producing an effervescent action and forcing debris to the surface. [7] In the late 20th century, studies conducted by Grossman and Meiman in 1941 led to the introduction of the combined

Use of double-strength sodium hypochlorite and hydrogen peroxide to wash out fragments of pulp tissue and dental shavings after mechanical instrumentation. This was published later in 1943 by Grossman. [8] At present, sodium hypochlorite has been recommended for day-to-day clinical practice

Function of irrigation(Nisha Garg. Amit Garg2010)

Irrigation is an important part of root canal treatment because it

➢ Perform physical and biologic functions ,,Dentin shavings get removed from canals by irrigation Thus, they do not get packed at the apex of root canal

➢ Lubrication,Instruments do not work properly in dry canals. Their efficiency increases in wet canals. Instruments are less likely to break when canal walls are lubricated with irrigation.

➢ Act as solvent of necrotic tissue, so they loosen debris, pulp tissue and microorganisms from irregular dentinal walls

➢ Help in removing the debris from accessory and lateral canals where instruments cannot reach.

➢ Most irrigants are germicidal but they also have antibacterial action.

➢ Also have bleaching action to lighten teeth discolored by trauma or extensive silver restorations.

➢ Though presence of irrigants in canal facilitate instrumentationbut simultaneous use of some lubricating agents (RC prep,REDTAC, Glyde, etc.) make the instrumentation easier and smoother.

CLASSIFICATION

Classification I

(A Contemporary Overview of Endodontic Irrigants A Review: J Dent App - Volume 1 Issue 6 - 2014)

A) Instrumentation auxiliary substances (used during instrumentation, do not needs

the optimal physical properties, only the chemical one)

- NaOCl (Sodium Hypochlorite)
- CHX (Chlorhexidine)
- EDTA (Ethylene Diamine Tetra Acetic Acid)
- Qmix

B) Irrigating substances (Used during irrigation aspiration procedure, have optimal physical properties, such as lower tension surface and lower viscosity).

- NaOCl,
- Saline,
- Distilled Water
- MTAD (Mixture of Tetracycline, Acid and Detergent)
- Tetraclean
- Qmix
- Herbal Alternatives Green Tea, Triphala

Classification-II

(Root canal irrigants: Journal of conservative dentistry-Volume-32 issue 4 2010)

Endodontic irrigants

A) Chemical agents

Tissue dissolving agents [e.g., NaOCl, ClO2]

Antibacterial agents

Bactericidal [e.g., CHX]

Bacteriostatic [e.g., MTAD1

Types of Irrigation solutions

Normal salineonne

Normal salineone of the solutions thatused as irrigant endodontics. It causes gross debridement and lubrication of root canals .Since it very mild in action, it can be used as an adjunct to chemical irrigant. It can also be used final rinse for root canals to remove any chemical irrigant left after root canal preparation .Normal saline as 0.9% W/V is commonly used(Nisha Garg. Amit Garg2010).

Advantages

Biocompatible solution with no adverse

effect even if extruded periapically, bebecau

osmotic pressure is the same as that of the blood .

Disadvantages

No dissolution, disinfectant and antimicrobial properties
Too mild to thoroughly clean the canal

Does not remove sear layer

Sodium hypochlorite

(NaOCl) is the most important irrigant in root canal treatment. 9,10,11]] It is the only presently used solution that can dissolve organic matter in the canal. [12,13,14] Therefore the use of hypochlorite is of utmost importance in removing necrotic tissue remnants as well as biofilm. NaOCl ionises in water into sodium (Na [+]) and the hypochlorite ions, OCl [–], and establishes an equilibrium with hypochlorous acid (HOCl). At acidic and neutral pH, most of the chlorine exists as HOCl, whereas at pH of nine and above, OCl [–] is most abundant. 15]] Hypochlorous acid has the strongest antibacterial effect while the OCl [–] ion is less effective. Hypochloric acid affects directly on the vital functions of the microbial cell, rapidly resulting in cell death. [16,17].

Hypochlorite is used in concentrations between 0.5-6%. 18,19,20,21]] To maximise the effectiveness of hypochlorite irrigation, the solution should be frequently refreshed and kept in motion by agitation or continuous irrigation. The speed of tissue dissolution can be increased with effective agitation and refreshment. [22,23] While several earlier studies have reported conflicting results of the comparative effectiveness of hypochlorite at different concentrations, recent studies have confirmed the superiority of high concentration hypochlorite over 1 and 2% solutions. [24,25] Hypochlorite should be used throughout the instrumentation, as the only solution at this stage, and for one to two minutes after completing the instrumentation. Alternating use of NaOCl and for example, ethylenediaminetetraacetic acid (EDTA) will abolish the antibacterial activity of the NaOCl and should be avoided. According to one recent study, tissue that has been exposed to EDTA is thereafter not effectively dissolved by NaOCl. [26] When smear layer removal is completed by EDTA, hypochlorite should not be used again as it causes erosion on dentine after EDTA or citric acid. [27] If hypochlorite comes into contact with chlorhexidine, an orange-brown precipitate that contains potentially carcinogenic para-chloroaniline (PCA) is formed. [28,29,30] Therefore, the canal should be rinsed, for example, with water or saline, between use of these two solutions.Sterile water and saline can be used between two irrigating solutions, for example, NaOCl and chlorhexidine, to prevent chemical reactions between them. However, water and saline must not be used as the main irrigants as they have neither tissue-dissolving nor antimicrobial activity. [31,32] The root canal space will be left with more tissue remnants and bacteria after treatment is completed if NaOCl and EDTA (see below) are not used.

ethylene diamin tetraacetic acid

EDTA is a chelator, which is used after NaOCl as the final irrigant. [33,34,35,36] EDTA solution is neutral or slightly alkaline; at an acidic pH EDTA precipitates. EDTA is usually used as a 17% or 15% solution, although some studies have suggested that 5% and even 1% EDTA solution is strong enough for smear layer removal. The recommended time for smear layer removal is around two minutes, but thick layers may require longer times of exposure. [30,37] The smear layer should be removed as it contains microbes and microbial antigens baked into it during instrumentation of the necrotic, infected root canal . [35,38] EDTA only affects the inorganic part of dentine and smear layer (hydroxyapatite) and complete removal of the smear layer can only be achieved when NaOCl has been used before the final rin se with EDTA.[39,40] EDTA has little or no antimicrobial activity, although some studies have indicated antifungal activity for EDTA. [41,42] However, EDTA weakens the bacterial cell membrane without killing the cell, but it may work in a synergistic manner with other chemicals, for example, chlorhexidine, which more vigorously attack the bacterial cell wall. [43] EDTA greatly weakens the effect of NaOCl and should not be used (mixed or alternating) with it. When mixed with chlorhexidine, EDTA forms a white, cloudy precipitate. [36,37,38,44]. Citric acid has a long history of use in root canal irrigation. It can be used instead of EDTA as the final rinse to remove the smear layer after use of NaOCl. One to ten percent solutions have been used. Citric acid is somewhat more aggressive than EDTA, and if NaOCl is used after citric acid (not recommended), the root canal wall erosion is more pronounced than in the EDTA–NaOCl sequence. [35] Citric acid is used as a component in MTAD and Tetraclean, the combination products for smear layer removal. [45,46]

Chlorhexidine

Chlorhexidine digluconate (CHX) is used in dentistry for plaque prevention and disinfection because of its good antimicrobial activity.47,48,49 It has also been much used in endodontics as a final irrigant after EDTA. CHX is cytotoxic to human cells but it does not cause pain comparable to NaOCl if accidentally extruded to the periapical area. CHX does not dissolve organic or inorganic matter and therefore it cannot be used as the only irrigating solution. CHX attacks the microbial cell wall or outer membrane resulting in killing of the microbe.25 However, it kills planktonic bacteria much more slowly than NaOCl; against biofilm bacteria its effect is equal to or lower than 1 and 2% NaOCl and much weaker than 5 or 6% NaOCl.32,33 CHX binds to hard tissue and remains antimicrobial (substantivity), which has been one reason for its use. However, the potential impact of the continued antimicrobial effect of CHX in the root canal has not been well examined

Several earlier studies that compared the antibacterial effect of NaOCl and 2% CHX against intracanal infection have shown little or no difference between their antimicrobial effectiveness.50,51,52,53However, recent studies using viability staining and more advanced biofilm models including a dentine biofilm model have shown that 6% NaOCl has a much stronger antibiofilm effect than 2% CHX, which is comparable or weaker than 1 and 2% NaOCl.32,33

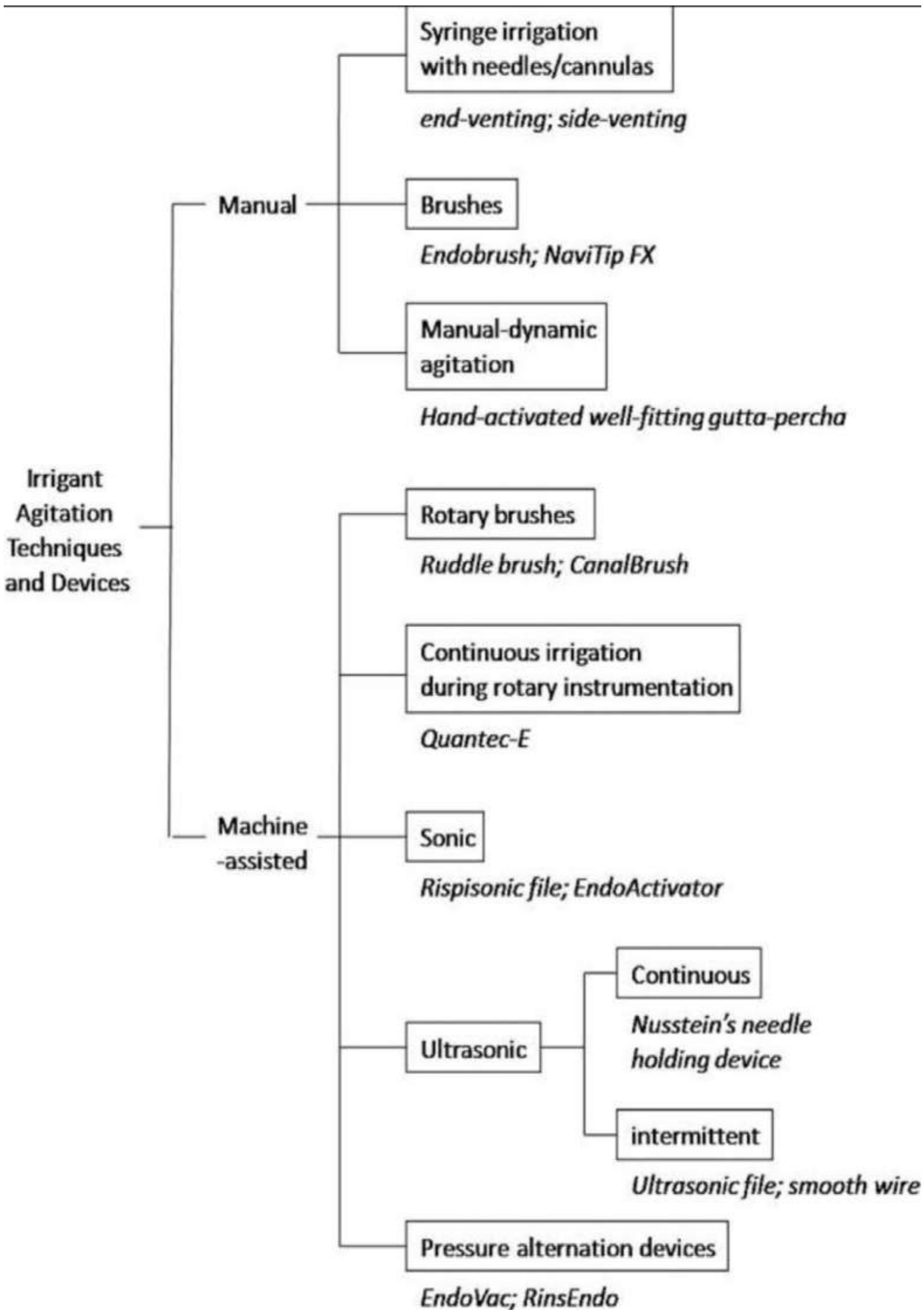
Although many bacteria may be killed by CHX, it cannot dissolve the biofilm or other organic debris. Residual organic tissue is likely to weaken the quality of the seal by the permanent root filling, necessitating the use of NaOCl as the main irrigant during instrumentation. On the positive side, CHX as the final rinse after EDTA does not cause erosion of dentine as NaOCl does; therefore 2% CHX may be considered for irrigation after the smear layer is removed.54

Much of the research in endodontics on the use of CHX has been done with Enterococcus faecalis; it is therefore possible that the studies have given too optimistic a picture of the usefulness of CHX as an antimicrobial agent in endodontics. A recent study suggested that use of CHX as the final rinse may in fact have a negative impact on the healing of apical periodontitis.55More research is needed to identify the optimal irrigation regimen for various types of endodontic treatments.

IRRIGATION DEVICES

IRRIGATION DEVICES Benjamin et al in 2007 compared the Endovac with needle irrigation on root canals and concluded that there was significantly better debridement 1 mm from working length for the Endovac System compared with needle irrigation and the volume of irrigant delivered with the Endovac System was significantly more than the volume delivered with needle irrigation over the same amount of time. 56 Uroz et al evaluated the effectiveness of the Endo Activator System in removing the smear layer after rotary root canal instrumentation, with and without a final flush of 17%Ethylenediaminetracetic acid(EDTA) solution in coronal,middle and apical thirds and concluded that the EndoActivator system did not enhance the removal of smear layer as compared with conventional max-I-probe irrigation with NaOCl and EDTA. 57Rodig et al in 2010 compared the efficiency of a sonic device (Vibringe), syringe irrigation, and passive ultrasonic irrigation in the removal of debris from simulated root canal irregularities and concluded that passive ultrasonic irrigation is more effective than vibringe system of syringe irrigation in removing debris.the sonic device demonstrated significantly better results than syringe irrigation in the apical root canal third. 57Rebecca et al in 2012 assessed the effectiveness of Er:YAG laser fiberin removing the smear layer produced during root canal walls instrumentation and concluded That the Er:YAG fiber irradiation with EDTA 17% and NaOCl 2.5% had been demonstrated to be effective in removing smear layer, even in the apical third which is described as the hardest area to clean during endodontic treatment 58Meenu et al evaluated the cleaning efficacy of NaviTip, MAX- i-Probe and Endovac in removal of debris from the root canal at 1.5 and 3.5mm from the apex and concluded that Endovac removed significantly more debris followed by Max-I-Probe and NaviTip at both levels. 59Guerreiro et al in 2015 studied the effect of passive ultrasonic irrigation on enterrofecalis from root canals and concluded that PUI with 1%NaOCl contribute fordisinfection,but are unable to eliminate E.faecalis from the root canal system and the study suggested that the use of an irrigating solutionwith antimicrobial activity plays an essential role in root canal disinfection . 60Muhammed et al in 2014 evaluated and compared the ability of photodynamic therapy (PDT) with ultrasonic irrigation diode laser to disrupt an experimental microbial biofilm inside the root canal in a clinically applicable working time. This study concluded that the photodynamic therapy and diode laser groups had the maximal bacterial growth in culture and the group that was treated by ultrasonic irrigation and NaOCL and EDTA solutions had the best result with significant reduction of bacterial load and destruction of microbial biofilm. 61Manisha et al in 2014 evaluated the root canal debris removal after irrigation with EndoVac system and compared its efficiency with Max-I-Probe needles and concluded that EndoVac performed better in removing debris from the apical thirds of the Eroot canals. 62 Ozur et al in 2014 evaluated efficacy of MTAD and citric acid Solutions used with self-adjusting file system on smear layer and concluded that using the SAF system and continuous irrigation action with EDTA and MTAD solutions could overcome the difficulty of removing smear layer even in hard-to-reach regions of the root canal. 63Karatas et al in 2014 compared the effects of Vibringe, Endo Vac, nonactivated SAF and passive ultrasonic irrigation with a convectional syringe on the amount of apically extruded debris and non-activated SAF extruded significantly less than Vibringe,Endo Vac, passive ultrasonic and syringe irrigation. 64Elnaghy et al in 2016 assessed and compared the effectiveness of XP-endo finisher, Endoactivator and File agitation on debris and smear layer removal in curved root canals and concluded that effectiveness of XP-endo Finisher and EndoActivator groups revealed significantly lower debris and smear layer scores than the positive control, non-agitated, File agitation groups on the coronal, middle, and apical regions. Irrigation of curved root canals using XP-endo Finisher and EndoActivator methods appears to be more effective on debris and smear layer removal than the other tested groups. 66

Classification Of Irrigating Devices



SYRINGES AND NEEDLES

Conventional irrigation with syringes has been advocated as an efficient method of irrigant delivery before the advent of passive ultrasonic activation. This technique is still widely accepted by both general practitioners and endodontists. The technique involves dispensing of an irrigant into a canal through needles/cannulas of variable gauges, either passively or with agitation. The latter is achieved by moving the needle up and down the canal space.67 Irrigation tip gauge and tip design can have a significant impact on the irrigation flow pattern, flow velocity, depth of penetration, and pressure on the walls and apex of the canal.67

Needle tip-gauge33

Irrigation tip gauge will largely determine how deep an irrigant can penetrate into the canal.

21-gauge tip- an outer diameter of 0.82 mm and can reach the apex of an ISO size 80 canal

23-gauge tip- an outer diameter of 0.64 mm and can reach a ISO size 50 canal

25-gauge tip- an outer diameter of 0.51mm and can reach a ISO size 35 canal

30-gauge tip- an outer diameter of 0.31mm and can reach the apex of a ISO size 25 canal

27-gauge needles is the preferred needle tip size for routine endodontic procedures which has an outer diameter of 0.41mm.

Several studies have shown that the irrigant has only a limited effect beyond the tip of the needle because of the dead-water zone or sometimes air bubbles in the apical root canal, which prevent apical penetration of the solution

Needle tip design

The smaller needles allow delivery of the irrigant close to the apex; this is not without safety concerns. Several modifications of the needle-tip design have been introduced in recent years to facilitate effectiveness and minimize safety risks.67

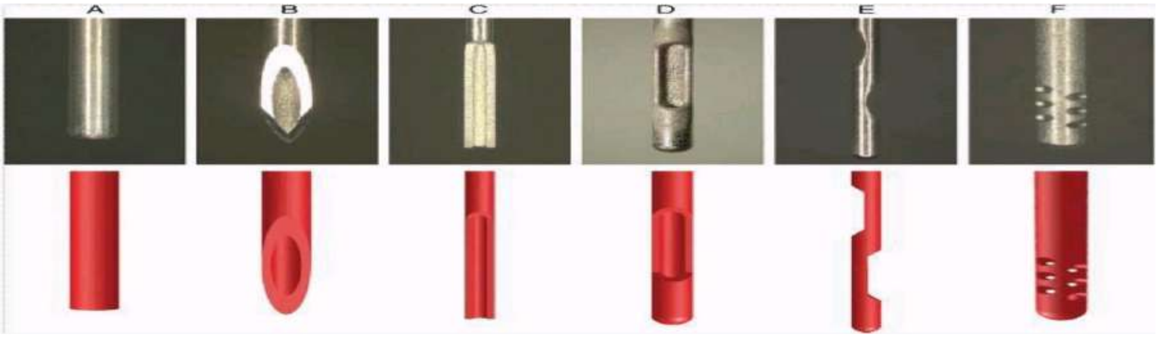
Open ended tips

These tips express irrigant out the end towards the apex and consequently increase the apical pressure within the canal.33 These tips can be flat((NaviTip; Ultradent), beveled (PrecisionGlide Needle; Becton Dickinson & Co) and notched (Appli- Vac Irrigating Needle Tip; Vista Dental)

Closed-ended tips

These are side-vented and thus create more pressure on the walls of the root canal and improve the hydrodynamic activation of an irrigant and reduce the chance of apical extrusion. This allows the irrigant to reflux and causes more debris to be displaced coronally, while avoiding the inadvertent expression of the irrigant into periapical tissues.67

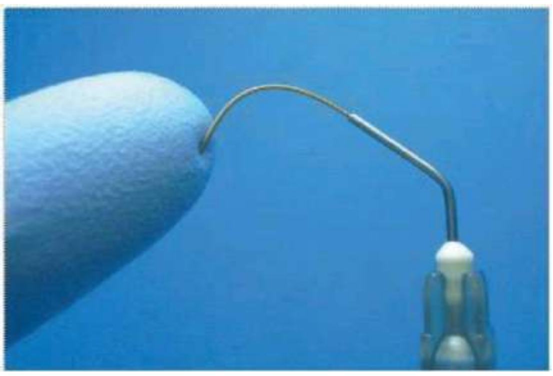
These tips can be side vented (KerrHawe Irrigation Probe; KerrHawe), double side vented (Endo-Irrigation Needle; Transcodent) and multivented (EndoVacMicrocannula; DiscusDental,CulverCity,CA).67



(A-C) Open-ended needles: (A) flat (NaviTip; Ultradent, South Jordan, UT), (B) beveled (PrecisionGlide Needle; Becton Dickinson& Co, Franklin Lakes, NJ), and (C) notched (Appli- Vac Irrigating Needle Tip; Vista Dental, Racine, WI). (D-F) Closed-ended needles: (D) side vented (KerrHawe Irrigation Probe; KerrHawe SA, Bioggio, Switzerland), (E) double side vented (Endo-Irrigation Needle; Transcodent, Neumu¨ nster, Germany), and (F) multivented (EndoVac Microcannula; Discus Dental, Culver City, CA

Flexiglide needle

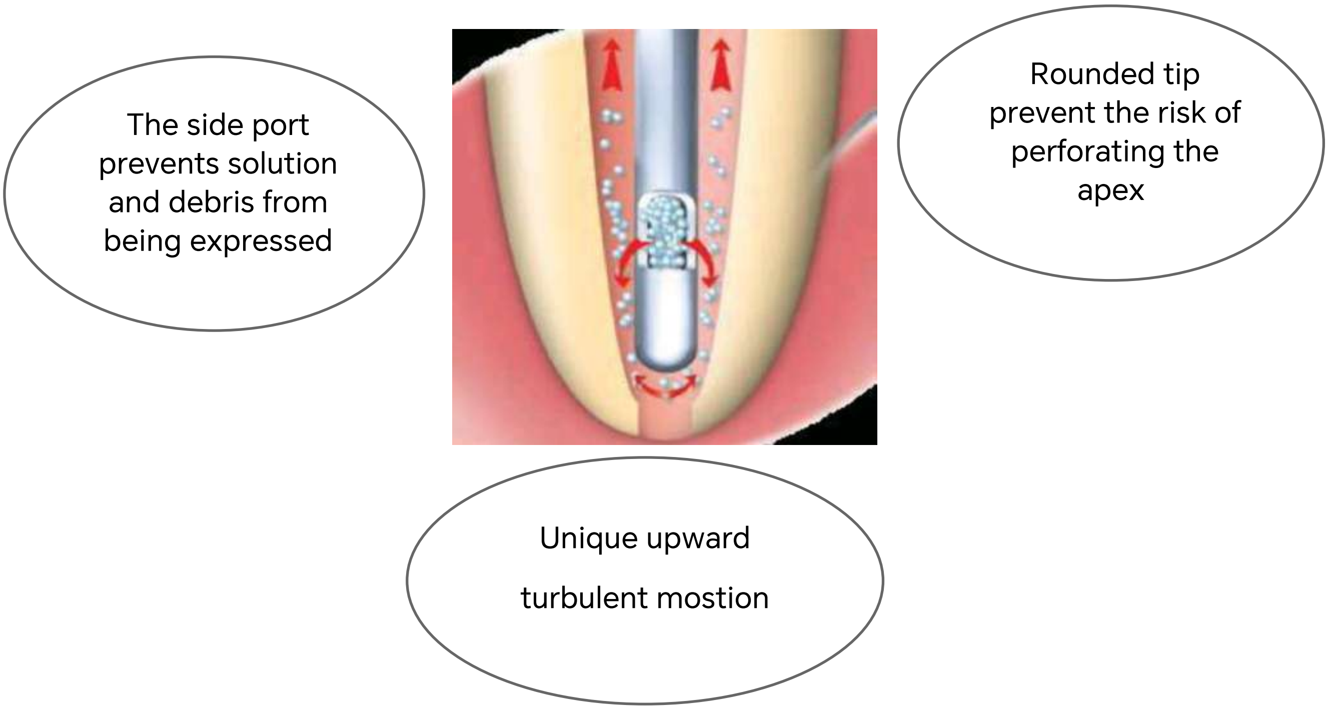
Vista dental flexiglide utility tips are disposable tips that are ideal for irrigation, application and micro aspiration. The flexible tip is made of fiber that can easily reach proper depth in a curved canal. Flexiglides flexible, crimp resistant tip facilitates access and provides maximum reach during canal procedures.



Flexiglide needle for irrigation easily follows curved canals

Max-I probe

Max-I-Probe (Dentsply International, York, PA) is a very commonly used manual irrigation system. It has a closed end irrigating probe with side-port dispersal that creates an upward flushing motion. The closed, round end reduces risk of apex damage. Kahn and others in their study found that Max-i -Probe was more effective in irrigation than the conventional needles routinely used.68



Refills		Size	Colour	Diameter	ISO
	40x	23G	Light Blue	0.6mm	70, 60, 55, 50
	40x	25G	Orange	0.5mm	45, 35
Endo version Highly flexible	40x	30G	Blue	0.3mm	30, 25, 20

Luer Lock connector

. Secure attachment and easy removal

. Fits on any disposable syringe

Navi-tip

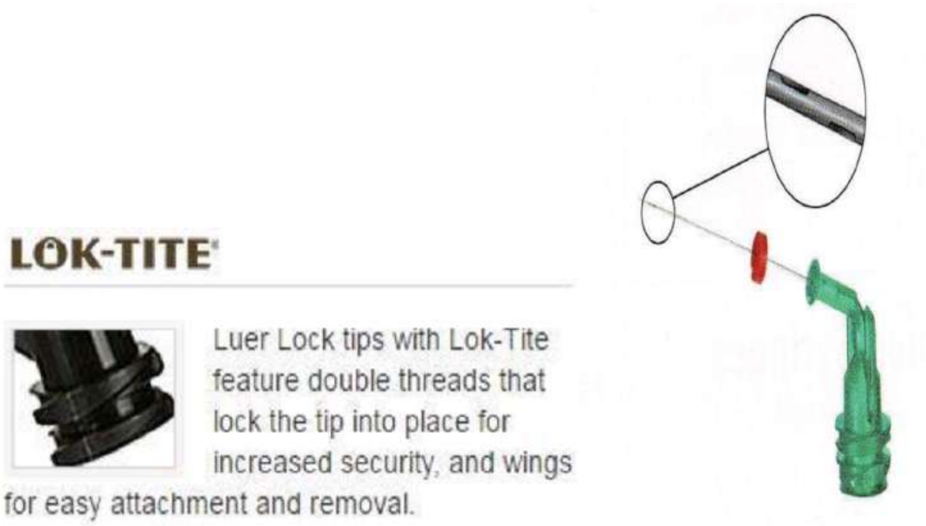
The cannula of each NaviTip is slightly rigid through the base and center, but flexible at the tip to allow for easy navigation of curved canals. Each NaviTip tip is color coordinated to match the corresponding endo file lengths, further simplifying their use. The flexible, stainless steel cannula easily navigates curved canals. NaviTip delivery tips are available in four lengths and two gauges. Available in 17, 21, 25, and 27mm lengths and 29- or 30-gauge cannula. match the corresponding endo file lengths69.

Navi-Tip Double Sideport35

.Double sideports deliver irrigants safely, minimizing the possibility of chemicals being expressed past the apex

.Available in 21mm and 27mm tip lengths with colour coded yellow and Green and it uses a31 gauge needle

.This tip features : LOK-TITE



Navitip Fx

. A 30-gauge irrigation needle covered with a brush (NaviTip FX; Ultradent Products Inc, South Jordan, UT) was introduced commercially. A recent study reported improved cleanliness of the coronal third of instrumented root canal walls irrigated and agitated with the NaviTip FX needle over the brushless type of NaviTip needle. However, friction created between the brush bristles and the canal irregularities might result in the dislodgement of the radiolucent bristles in the canals that are not easily recognized by clinicians, even with the use of a surgical microscopy. 69

. Available in 17mm or 25mm tip lengths with 30 gauge cannula and colour coded white and blue

. Has LOCK-TITE feature

Syringes

Plastic syringes of different sizes (1 20 mL) are most commonly used for irrigation.Although large-volume syringes potentially allow some time-savings, they are more difficult to control for pressure and accidents may happen. Therefore, to maximize safety and control, use of 1- to 5-mL syringes is recommended instead of the larger ones. All syringes for endodontic irrigation must have a Luer-Lok design70.

Manual-Dynamic Irrigation

An irrigant must be in direct contact with the canal walls for effective action. However, it is often difficult for the irrigant to reach the apical portion of the canal because of the so-called vapor lock effect. Research has shown that gently moving well -fitting gutta-percha master cone up and down in short 2 to 3 mm strokes (manualdynamic irrigation) within an instrumented canal can produce an effective hydrodynamic effect and significantly improve the displacement and exchange of any given reagent. This was recently confirmed by the studies of McGill et al., and Huang et.al. These studies demonstrated that manual-dynamic irrigation was significantly more effective than an automated-dynamic irrigation system (RinsEndo; Duerr Dental Co, Bietigheim-Bissingen, Germany) and static irrigation 70.

Factors Affecting Manual Dynamic Irrigation

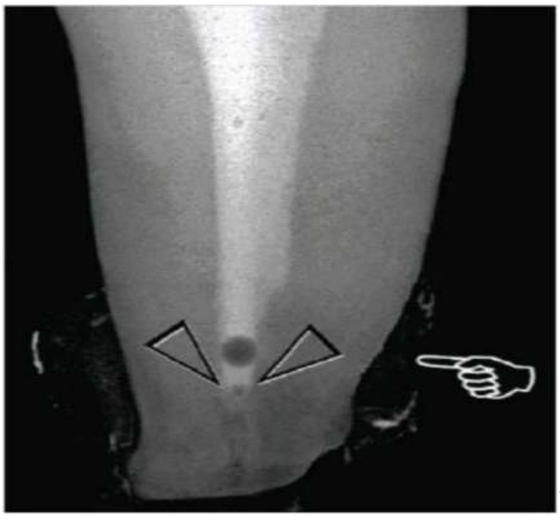
1) The push-pull motion of a well fitting gutta-percha point in the canal might generate higher intracanal pressure changes during pushing movements, leading to more effective delivery of irrigant to the "untouched" canal surfaces 70.

2)) the frequency of push-pull motion of the gutta-percha point (3.3 Hz, 100 strokes per 30 seconds) is higher than the frequency (1.6 Hz) of positive-negative hydrodynamic pressure generated by RinsEndo, possibly generating more turbulence in the canal.

3) The push-pull motion of the gutta-percha point probably acts by physically displacing, folding, and cutting of fluid under,,viscously_dominated flow,,in the root canal system.70

Vapour Lock Effect

Air entrapment by an advancing liquid front in closed-end microchannels is a wellrecognized physical phenomenon and has been referred to as the vapour lock effect in the endodontic literature. The ability of a liquid to penetrate these closed-end channels is dependent on the contact angle of the liquid. This vapour lock can be disrupted using manual dynamic irrigation 70.

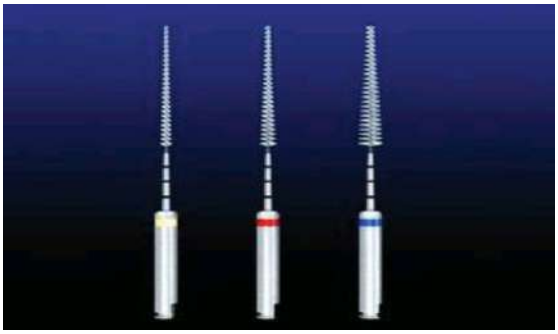


Vapor lock effect

Rotary Brushes

Ruddle Brush

A rotary handpiece attached microbrush has been used to facilitate debris and smear layer removal from instrumented root canals introduced by Clifford J Ruddle.The brush includes a shaft and a tapered brush section. The latter has multiple bristles extending radially from a central wire core. Bristles can be attached to a flexible plastic core material and the brushes activated utilizing a rotary handpiece to optimally finish the root canal preparation. The brush section has a diameter of between about 0.2 mm and about 0.5 mm at a tip end and a diameter of between about 1 mm and 2 mm at its coronal end. The brush section is about 16 mm long, and thus has a taper of between about 0.06 mm/mm and about 0.12 mm/mm. During the debridement phase, the microbrush rotates at about 300 rpm, causing the bristles to deform into the irregularities of the preparation. This helps to displace residual debris out of the canal in a coronal direction 70.





Canal Brush

Canal Brush is another endodontic microbrush which is a highly flexible microbrush that is molded entirely from polypropylene and might be used manually with a rotary action or for more efficiency its used with contra-angle handpiece. The CanalBrush (Coltene, Germany) is available in three sizes (small, medium and large), which correspond to apical diameter of 25, 30 and 40 respectively, according to the ISO classification.The manufacturer recommends this brush to be used in conjunction with NaOCl at a maximum speed of 650 rpm for up to 30 s.71

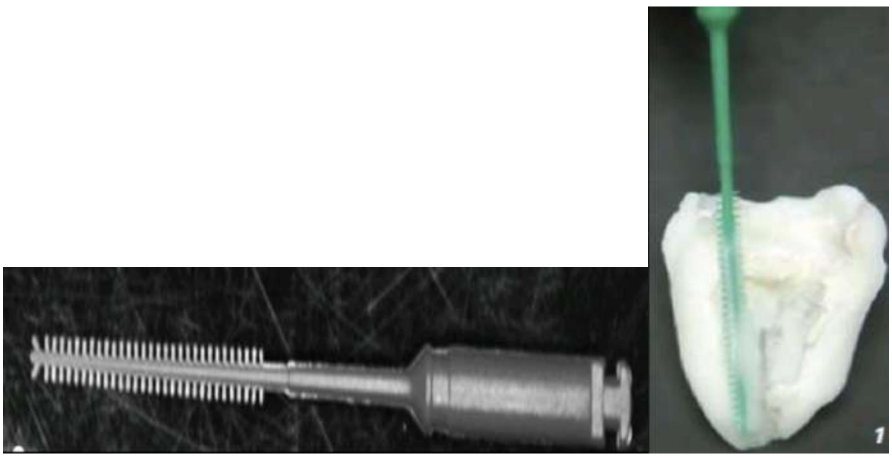
Advantages:

.Better cleaning effect than with files, without enlarging the canal

. Very flexible, low risk of breakage

. Can be autoclaved at 134°Cbefore use

. Can be used to place Post cement and adhersives



Continuous irrigation during rotary instrumentation during rotary instrumentation

Quantec-E

The Quantec-E irrigation system was introduced by SybronEndo company is a selfcontained fluid delivery unit that is attached to the Quantec-E Endo System. It uses a pump console, 2 irrigation reservoirs, and tubing to provide continuous irrigation during rotary instrumentation. It has been proposed that continuous irrigant agitation during active rotary instrumentation would generate an increased volume of irrigant, increase irrigant contact time, and facilitate greater depth of irrigant penetration inside the root canal. This should result in more effective canal debridement.According to Setlock et al , compared with needle irrigation. Irrigation with this results in cleaner canal walls and more complete debris and smear layer removal in the coronal third of the canal walls. However, these advantages were not observed in the middle and apical thirds of the root canal.70

Sonic Irrigating Devices

Sonic instruments for endodontics were first reported by Tronstad et al. Sonic irrigation operates at a lower frequency 6 1) kHz) and produces smaller shear stresses than ultrasonic irrigation Ahmed et al.

The Vibringe

The Vibringe System an irrigation device that combines manual delivery and sonic activation of the solution has been introduced by a Dutch company Vibringe B. V. The Vibringe is a cordless handpiece that fits in a special disposable 10-mL LuerLock syringe that is compatible with every irrigation needle.The Vibringe allows delivery and sonic activation of the irrigating solution in one step. It employs a 2-piece syringe with a rechargeable battery.72

The irrigant is sonically activated, as is the needle that attaches to the syringe. This induces an acoustic streaming process in the root canal to remove necrotic tissue, debris, bacteria and biofilm faster and more effectively. Activation prevents air entrapment in the root canal enabling the irrigation solution to reach and disinfect all areas of the root canal system, including the apical region.72

Rödig et al evaluated the efficacy of vibringe system they concluded that vVibringe demonstrated significantly better results than syringe irrigation in the apical root canal third in removing debris. However it was not as effective as the passive ultrasonic irrigation

Endoactivator

The EndoActivator® is designed to safely and vigorously energize the hydrodynamic phenomenon(Dentsply Tulsa Dental). Evidence-based endodontics has shown that cavitation and acoustic streaming significantly improve debridement and the disruption of the smear layer and biofilm. Activating fluids promote deep cleaning and disinfection into lateral canals, fins, webs, and anastomoses.

Principle

The hydrodynamic phenomenon results when a vibrating tip generates fluid activation and intracanal waves. The metaphor is vibratory energy within a wellshaped and fluid-filled canal serves to induce intracanal waves. Random waves fracture, creating bubbles that oscillate within any given solution. These bubbles expand and become unstable, then collapse in what is termed an implosion. Each implosion radiates miniature tsunamis, or shockwaves that dissipate at 25,000 to 30,000 times per second (Gutarts et al, 2005). Shockwaves serve to powerfully penetrate, break up potential bacterial infested biofilms and wipe surfaces clean. Imploding bubbles serve to desirably increase the temperature and further generate significant pressure on an intracanal irrigant, which in a small microscopic space serves to promote surface cleaning.73The EndoActivator System (Advanced Endodontics) is comprises of a handpiece and variously sized polymer tips. This sonically-driven system is designed to safely activate various intracanal reagents and vigorously produce the hydrodynamic phenomenon. This technology is intended to provide a safer, better and faster method to disinfect a root canal system compared to other currently available methods. Research has shown, and is showing, that the EndoActivator System is able to debride into the deep lateral anatomy, remove the smear layer and dislodge simulated biofilm clumps within the curved canals of molar teeth (Caron, 2007; Gulabivala, 2006). During use, the action of the EndoActivator tip frequently produces a cloud of debris that can be observed within a fluid-filled pulp chamber. The primary function of the EndoActivator is to produce vigorous intracanal fluid agitation through acoustic streaming and cavitation. This hydrodynamic activation serves to improve the penetration, circulation and flow of irrigant into the more inaccessible regions of the root canal system (Guerisolo et al, 2002).73

This clinical image shows the EndoActivator System in use. Note the fluid activation and appreciate the potential for enhanced cleaning.

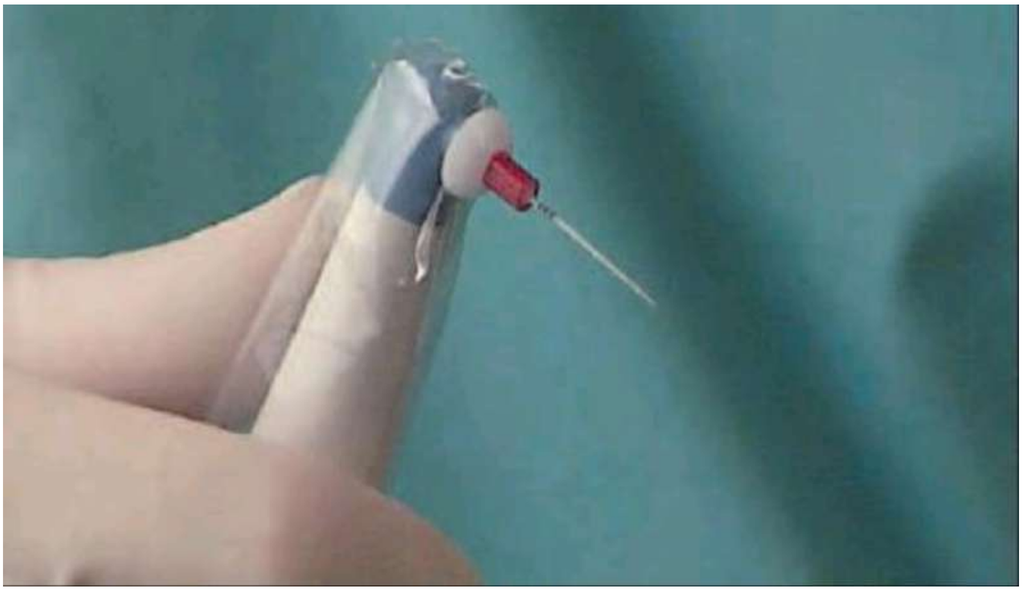
Preliminary research is showing the EndoActivator, utilizing polymer tips, is a safe and effective method to both adapt and remove calcium hydroxide from a shaped canal. Further, this technology may be used, in straight or more curved canals, to deliver mineral trioxide aggregate (MTA, Dentsply Tulsa Dental Specialties) into immature teeth exhibiting blunderbuss canals, or into perforating pathological or iatrogenic defects. In the retreatment situation, clinical trials have shown that the EndoActivator System serves to break up and dislodge remnants of previously placed obturation materials.

Sonic Handpiece

The sonic handpiece is cordless, contra-angled, and ergonomic, and is used to drive the EndoActivator tips. The handpiece is operated by depressing the light-touch on/off switch that activates the strong and flexible polymer tips. The three-speed sonic motor switch provides options of 10,000, 6,000 and 2,000 cycles per minute (cpm). When the handpiece is activated, the power defaults to 10,000cpm, which research has shown to be the recommended speed to maximize debridement and disruption of the smear layer and biofilm (Caron, 2007;Gulabivala, 2006). The sonic motor is energized by, preferably, a single lithium battery. Depending on use, periodically install a new, fully charged battery to ensure optimal performance. For infection control, custom protective barrier sleeves have been designed to easily slide over the entire handpiece. It is important not to autoclave or submerge the handpiece in cleaning solutions; rather, simply wipe down the handpiece, as desired, with a mild detergent.73

Endoactivator Tips

The EndoActivator tips have an easy snap-on/snap-off design and are color-coded yellow, red and blue, corresponding to small, medium and large sizes, respectively.Specifically, the yellow, red and blue color-coded activator tips closely correspond to file nomenclature sizes 20/02, 25/04, and 30/06, respectively. The tips are made from a medical-grade polymer, are strong and flexible, and are 22mm long. Importantly, the polymer tips will not cut dentin, and as such, will not ledge, apically transport, or perforate a canal. The bowl shaped, clean -guard serves to consolidate the protective barrier to maximize vision during clinical use. Each activator tip has orientational depth gauge rings positioned at 18, 19 and 20mm. The EndoActivator tips are disposable, single-use devices that should not be autoclaved. At times, the orthodontic Bird Beak pliers can be used to place a smooth curve on any sized tip to facilitate their placement. Also, the apical extent of any given tip can be cut off and the overall length appropriately shortened to facilitate placement and treatment. The EndoActivator tip selected is placed over the barrier-protected driver and is simply snapped on to secure its connection to the handpiece.73



The Activator tip is selected, is placed over the barrier protected driver, and will snap-on firmly to promote a secure connection

Tip selection

In fully prepared canals, a tip is selected that fits loosely and to within 2mm of working length. A loose tip will be free to move, enhancing irrigation dynamics (Ahmad, Pitt-Ford and Crum, 1987b). An underprepared canal or selecting a tip that is too large will serve to dampen or restrict tip movement, which in turn will limit its ability to agitate a solution. When the selected tip moves toward the full working length, its shape more closely approximates the shape of the prepared canal. This, in turn, serves to displace any given reagent laterally while allowing safe reflux coronally. Vibrating the tip, in combination with moving the tip up and down in short vertical strokes, synergistically produces a powerful hydrodynamic phenomenon. In general, 10,000cpm has been shown to optimize debridement and promote the disruption of the smear layer and biofilm (Caron, 2007; Gulabivala, (2006)37.

When the clinical procedure has been completed, support the contra-angled neck of the handpiece and remove the attached activator tip by pulling straight off. Together the activator tip and barrier sleeve should be discarded.

Clinical Applications

The EndoActivator® System is designed to provide a safer, better, and faster way to achieve success in the following clinical applications:

. Debridement and disruption of the smear layer and biofilm

. Placement of calcium hydroxide and MTA around root curvatures

. Removal of residual obturation materials during retreatment procedures

Ultrasonics

Ultrasound is a vibration or acoustic wave of the same nature as sound but at a frequency higher than the highest frequency perceptible to the human ear (approximately 20,000 Hz). Ultrasonic devices were first introduced in Endodontics by Richman (1957). Ultrasonically activated files have the potential to prepare and debride root canals mechanically. The files are driven to oscillate at ultrasonic frequencies of 25 30 kHz that are beyond the limit of human hearing. The files operate in a transverse vibration, setting up a characteristic pattern of nodes and antinodes along their length (Walmsley 1987, Walmsley & Williams 1989). It has been shown that ultrasonically driven files are effective for the, irrigation, of root canal 74

Two types of ultrasonic irrigation have been described in the literature

CONTINUOUS ULTRASONIC IRRIGATION

It is where irrigation is combined with simultaneous ultrasonic instrumentation (UI)During UI the file is intentionally brought into contact with the root canal wall. UI has been shown to be less effective in removing simulated pulp tissue from the root canal system or smear layer from the root canal wall (Weller et al. 1980, Ahmad et al. 1987a). This can be explained by a reduction of acoustic streaming and cavitation (Ahmad et al. 1987a). As the root canal anatomy is complex (Peters 2004) an instrument will never contact the entire root canal wall (Wu et al. 2003). Thus, UI could result in uncontrolled cutting of the root canal wall without effective cleaning.75

Nussteins needle holding device

Nusstein developed a needle-holding adapter to an ultrasonic handpiece.During ultrasonic activation, a 25-gauge irrigation needle is used instead of an endosonic file. This enables ultrasonic activation to be performed at the maximum power setting without causing needle breakage. In this continuous ultra sonic irrigation system the needle is simultaneously activated by the ultrasonic handpiece, while an irrigant is delivered from intravenous tubing connected via a Luer-lok to an irrigation-delivering syringe. The irrigant can thus be delivered apically through the needle under a continuous flow instead of being intermittently replenished from the coronal access opening. Various studies demonstrated that 1 minute of continuous ultrasonic irrigation produced significantly cleaner canals and isthmi in both vital and necrotic teeth75

Passive Ultrasonic Irrigation

Passive ultrasonic irrigation was first described by Weller et al. 1980)). The term.‹passive,does not adequately describe the process, as it is in fact active, however,when it was first introduced the term, passive, related to the, noncutting, the ultrasonically activated file.

Principle

PUI relies on the transmission of acoustic energy from an oscillating file or smooth wire to an irrigant in the root canal. The energy is transmitted by means of ultrasonic waves and can induce acoustic streaming and cavitation of the irrigant (Ahmad et al. 1987a, b, Ahmad et al. 1988, Lumley et al. 1991, Ahmad et al. 1992, Royet al. 1994) 74

Clinical procedure

After the root can4zr2al has been shaped to the master apical file (irrespective of the preparation technique used), a small file or smooth wire (form example size 15) is introduced in the center of the root canal, as far as the apical region. The root canal is then filled with an irrigant solution and the ultrasonically oscillating file activates the irrigant. As the root canal has already been shaped, the file or wire can move freely and the irrigant can penetrate more easily into the apical part of the root canal system (Krell et al. 1988) and the cleaning ,effect will be more powerful (Ahmad et al. 1987, 1988, 1992 Lumley et al. 1991, Roy et al. 1994). A file larger than size 15 or will only oscillate freely in a wide root canal. A size 25 file 20 may in fact produce less acoustic streaming than a size 15 and file (Ahmad et al. 1987b). The cleaning efficacy of PUI 20 implies the effective removal of dentine debris microorganisms (planktonic or in biofilm) and organic tissue from the root canal. Because of the active streaming of the irrigant its potential to contact a greater surface area of the canal wall will be enhanced.74

produce more cycles per second, 40 as against 24 kHz. The tips of these units workin a linear movement from back to front like a piston which is ideal for endodontic treatment. 74

The properties of the ultrasonic material determine the frequency of the oscillating instrument, which in dental practice, is fixed at 30 kHz. The intensity or energy flux

expressed in units of Watt cm)2, of the oscillating instrument can be adjusted by the power setting. A higher frequency should in principle result in a higher streaming velocity of the irrigant, this in turn results in a more powerful acoustic streaming.74

Pressure alteratlon device

There are apparently dilemmatic phenomena associated

with conventional syringe needle delivery of irrigants. It is desirable for the irrigants to be in direct contact with canal walls for effective debris debridement and smear layer removal. Its difficult to reach the apical portion of the canal due to air entrapment39 when the needle is placed away from the canal. If the needle is placed so close to the apical formen increased chance of irrigant extrusion from the .foramen causes iatrogenic damage to the periapical tissues Concomitant irrigant delivery and aspiration through the use of pressure alternation devices provide a plausible solution to this problem76

A)ENDOVAC SYSTEM

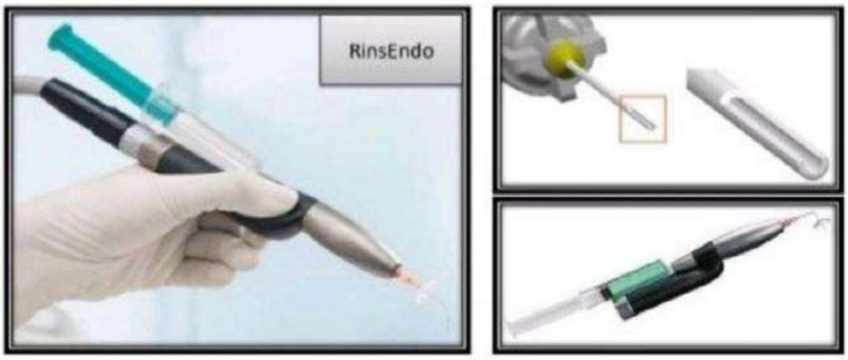
Endo Vac apical negative pressure irrigation was given by Discus Dental Company. It uses suction technique which wash out the debris and encourage the flow of irrigation in apical two third of the canal. It has three components: The Master Delivery Tip, Macro Cannula and Micro Cannula. The Master Delivery Tip simultaneously delivers and evacuates the irrigant. The MacroCannula is used to suction irrigant from the chamber to the coronal and middle segments of the canal. The MacroCannula or MicroCannula is connected via tubing to the high-speed suction of a dental unit. The Master Delivery Tip is connected to a syringe of irrigant and the evacuation hood is connected via tubing to the highspeed suction of a dental unit.The plastic macrocannula has a size open end with a .02 taper and is attached to a 55 titaniumhandle for gross, initial flushing of the coronal part of the root canal. The size 32 stainless steel microcannula has 4 sets of 3 laser-cut, laterally positioned, offset holes adjacent to its closed end. This is attached to a titanium finger-piece for irrigation of the apical part of the canal by positioning it at the working length. The micro-cannula can be used in canals that are enlarged to size 35 or larger. During irrigation, the delivery/evacuation tip delivers irrigant to the pulp chamber and siphons off the excess irrigant to prevent overflow. The cannula in the canal simultaneously exerts negative pressure ,that pulls irrigan tfrom its fresh supply in the chamber

Figure 15

down the canal to the tip of the cannula, into the cannula, and out through the suction hose. Thus, a constant flow of fresh irrigant is being delivered by negative pressure to working length. Endo vac has the ability to safely deliver the irrigants to working length without causing extrusion into the peri apical region(77,78

B)RINS ENDO SYSTEM

Rins Endo was introduced byDurr Dental Co.its based on pressure suction technology with aproximately 100 cycles per minute(79). Its components are a handpiece, a cannula with a mm exit aperture, and a syringe carrying irrigant. The 7 handpiece is powered by a dental air compressor and has an irrigation speed of 6.2 ml/min. With this system, 65 mL of a rinsing solution oscillating at a frequency of 1.6 Hz is drawn from an attached syringe and transported to the root canal through an adapted cannula. During the suction phase,the used solution and air are extracted from the root canal and automatically merged with a fresh rinsing solution. The pressure-suction cycles change approximately 100 times per minute. The manufacturer of RinsEndo claims that the apical third of the canal might be effectively rinsed, with the cannula restricted to the coronal third of the root canal .because of the pulsating nature of the fluid flow. McGill et al evaluated the effectiveness of RinseEndo system in a split tooth model. They found to be less effective in removing the stained collagen from root canal walls when compared with manual- dynamic irrigation by hand agitation of the instrumented canals with well-fitting gutta- percha points(80



RinsEndo

PHOTOACTIVATED DISINFECTIO

Photo activated disinfection (PAD) in endodontic irrigation : has been introduced in order to minimize or eliminate residual bacteria in the root canal. PAD technique employs a non-toxic dye,termed a photosensitizer (PS), and low ,intensity visible light which, in the presence of oxygen combine to produce cytotoxic species. The principle on which it operates is that PS molecules attach to the membrane of the bacteria.Irradiation with light at a specific wavelength matched to the peak absorption of the PS leads to the production of singlet oxygen, which causes the bacterial cell wall to rupture, killing the bacteria.PAD is also effective against viruses,fungi and protozoa (81)(82) The PS is a watery solution of toluidine blue O (TBO) that attaches to the membranes of microorganisms and binds itself to their surface, absorbs energy from the light and then releases this energy to oxygen (O_2), which is transformed into highly reactive oxygen species (ROS), such as oxygen ions and (radicals(83

Figure (17

OZONE BASED DELIVERY SYSTEM

Ozone is a triatomic molecule consisting of three oxygen atoms. It is applied to oral tissues in the forms of ozonated water, ozonated olive oil and oxygen/ozone gas. It is unstable and dissociates readily back into oxygen (O_2), thus liberating so-called singlet oxygen (O_1), which is a strong oxidizing agent which further impose the deleterious effect on microorganisms. Various delivery systems available for ,endodontic irrigation like Neo Ozone Water-S unit HealOzone (Kavo) unit, the OzoTop unit. Nagayoshi et al.found that ozonated water (0.5–4 mg/L) was

highly effective in killing both gram positive and negative (micro-organisms(84

Figure (18

LASER

Lasers have been recently proposed to activate irrigation -solutions by the transfer of pulsed energy(85)(86) Laser activated irrigation by Er:YAG and Er,Cr:YSGG laser light has been suggested to be more effective in removing dentin debris and smear layer.The use of laser is to enhance the . (antimicrobial action of sodium hypochlorite(87)(88 Numerous studies have found that Er:YAG is the most .appropriate laser for intra canal debris and smear removal The laser energy emitted from the tip of the optical fiber is directed along the canal and not necessarily lateral to the walls. To overcome this limitation, a delivery system that allows lateral emission of the radiation aimed to improve the antimicrobial effect53 , but a complete elimination of the biofilm and bacteria was not yet possible(89)(90) . In conclusion, there is still no strong evidence to support the application of high-power lasers for direct disinfection of root canals(91)(92

CONCLUDING

Root canal irrigation is a common theme in the endodontic literature, but progress in a field is not a mere function of the number of published studies. Certain topics, such as debris and smear layer removal, have been investigated very extensively, whereas others, such as the penetration of the irrigants in the root canal system and their effect on the biofilm or on the long-term treatment outcome, have gained much less attention. Hence there is a clear need to redefine the research priorities in this field. New studies must also focus on clinically relevant comparisons, avoid methodological flaws and have sufficiently large sample sizes to reach valid conclusions. A systematic search of the literature on almost any topic on root canal irrigation will provide numerous examples of studies that did not adhere to these basic principles but were nevertheless published. This problem is .(neither new nor specific to root canal irrigation (Altman, 1994 Therefore, instead of striving to produce more studies, the attention should be put on producing better studies.Based on the current body of knowledge, NaOCl and EDTA delivered by a syringe and needle and possibly activated by an ultrasonic .file remain the cornerstone of root canal irrigation protocols Future multidisciplinary efforts combining the knowledge from basic sciences such as Chemistry, Microbiology and Fluid Dynamics could eventually lead to more effective antimicrobials and improved activation methods to bring .them closer to the residual biofilm in the root canal system

Reference

1) Shaheen Venghat, Mithra Hegde, Chitharanjan Shetty. Irrigants used in endodontics Int.J.Curr.Microbiol.App.Sci 126-132 :(3)3 (2014)

2) Agrawal Vineet S, Mahant Rajesh, Kapoor Sonali, Patel Mukesh. .Contemporary Overview of Endodontic Irrigants A Review J Dent 105_115:(6)1,2014

3) Gary Glassman. Endodontic irrigants and irrigant delivery systems Roots 1-2013

4) Root Canal Irrigants and disinfection: Endodontics Colleagues for Excellence Winter 2011

5) Taft J. A practical treatise on operative dentistry. London: Trubner and Co., 1859:244.

5) Schreier EO. The treatment of infected root canals with kalium and natrium. Dent Cosmos 1893;38:863.

6) Callahan JR. Sulfuric acid for opening root canals. Dent Cosmos 1894:36:329.

8) Grossman Ll. Irrigation of the root canals. J Am Dent Assoc 1943:30:1915-7

9)Siqueira JF Jr, Rôças I N, Favieri A, Lima K C . Chemomechanical reduction of the bacterial population in the root canal after instrumentation and irrigation with 1%, 2.5%, and 5.25% sodium hypochlorite. J Endod 2000; 26: 331–334.

10)Dunavant T R, Regan J D, Glickman G N, Solomon E S, Honeyman A L . Comparative evaluation of endodontic irrigants against Enterococcus faecalis biofilms. J Endod 2006; 531–527 :32.

11) Williamson A E, Cardon J W, Drake D R . Antimicrobial susceptibility of monoculture biofilms of a clinical isolate of Enterococcus faecalis. J Endod 2009; 35: 95–97.

12) Beltz R E, Torabinejad M, Pouresmail M . Quantitative analysis of the solubilizing action of MTAD, sodium hypochlorite, and EDTA on bovine pulp and dentin. J Endod 337–334 :29 ;2003

13) Cobankara F K, Ozkan H B, Terlemez A . Comparison of organic tissue dissolution capacities of sodium hypochlorite and chlorine dioxide. J Endod 2010; 36: 272–274.

14)) Stojicic S, Zivkovic S, Qian W, Zhang H, Haapasalo M . Tissue dissolution by sodium hypochlorite: effect of concentration, temperature, agitation, and surfactant. J Endod 1562–1558 :36 ;2010.

15) Mcdonnell G, Russell D . Antiseptics and disinfectants: activity, action, and resistance. Clin Microbiol Rev 1999; 12: 179–147

16) Barrette WC Jr, Hannum D M, Wheeler W D et al. General mechanism for the bacterial toxicity of hypochlorous acid: abolition of ATP production. Biochemistry 1989; 28: 9172–9178.

17) McKenna S M, Davies K J . The inhibition of bacterial growth by hypochlorous acid. Biochem J 1988; 254: 685–692

18) Harrison J W, Hand R E . The effect of dilution and organic matter on the anti-bacterial property of 5.25% sodium hypochlorite. J Endod 1981; 7: 128–132.

19) Gomes B P, Ferraz C C, Vianna M E, Berber V B, Teixeira F B, Souza-Filho F J. In vitro antimicrobial activity of several concentrations of sodium hypochlorite and chlorhexidine gluconate in the elimination of Enterococcus faecalis. Int Endod J 2001; 34: 424–428

20) Zehnder M . Root canal irrigants. J Endod 2006; 32: 389–398.

21) Clegg M S, Vertucci F J, Walker C, Belanger M, Britto L R . The effect of exposure to irrigant solutions on apical dentin biofilms in vitro. J Endod 2006; 32: 434–437.

22) Klyn S L, Kirkpatrick T C, Rutledge R E . In vitro comparisons of debris removal of the EndoActivator system, the F file, ultrasonic irrigation, and NaOCl irrigation alone after hand-rotary instrumentation in human mandibular molars. J Endod 2010; 36: 1367–1371.

23) Johnson M, Sidow S J, Looney S W, Lindsey K, Niu L N, Tay F R . Canal and isthmus debridement efficacy using a sonic irrigation technique in a closed-canal system. J Endod 2012; 1268–1265 :38.

24) Ma J, Wang Z, Shen Y, Haapasalo M . A new noninvasive model to study the effectiveness of dentin disinfection by using confocal laser scanning microscopy. J Endod 2011; 37: 1385–1380.

25) Wang Z, Shen Y, Haapasalo M . Effectiveness of endodontic disinfecting solutions against young and old Enterococcus faecalis biofilms in dentin canals. J Endod 2012; 38: 1376–1379.

26) Spangberg L, Engstrom B, Langeland K . Biologic effects of dental materials. 3. Toxicity and antimicrobial effect of endodontic antiseptics in vitro. Oral Surg Oral Med Oral Pathol 871–856 :36 ;1973.

27) Qian W, Shen Y, Haapasalo M . Quantitative analysis of the effect of irrigant solution sequences on dentin erosion. J Endod 2011; 37: 1437–1441.

28) Marchesan M A, Pasternak Junior B, Afonso M M, Sousa-Neto M D, Paschoalato C . Chemical analysis of the flocculate formed by the association of sodium hypochlorite and chlorhexidine. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007; 103: 103–105

29) Basrani B R, Manek S, Sodhi R N, Fillery E, Manzur A . Interaction between sodium hypochlorite and chlorhexidine gluconate. J Endod 2007; 33: 966–969.

30) Basrani B R, Manek S, Fillery E . Using diazotization to characterize the effect of heat or sodium hypochlorite on 2.0%

chlorhexidine. J Endod 2009; 35: 1296–1299.

31） Byström A, Sundqvist G . Bacteriologic evaluation of the effect of 0.5 percent sodium hypochlorite in endodontic therapy. Oral Surg Oral Med Oral Pathol 1983; 55: 307–312.

32） Byström A, Sundqvist G . The antibacterial action of sodium hypochlorite and EDTA in 60 cases of endodontic therapy. Int Endod J 1985; 18: 35–40

33) Loel D A . Use of acid cleanser in endodontic therapy. J Am Dent Assoc 1975; 90: 148–151.

34) Baumgartner J C, Brown C M, Mader C L, Peters D D, Shulman J D . A scanning electron microscopic evaluation of root canal debridement using saline, sodium hypochlorite, and citric acid. J Endod 1984; 10: 525–531.

35) Baumgartner J C, Mader C L . A scanning electron microscopic evaluation of four root canal irrigation regimens. J Endod 1987; 13: 147–157.

36) Czonstkowsky M, Wilson E G, Holstein F A . The smear layer in endodontics. Dent Clin North Am 1990; 34: 13–25

37） Hülsmann M, Heckendorff M, Lennon A . Chelating agents in root canal treatment: mode of action and indicaülsmanntions for their use. Int Endod J 2003; 36: 810–830.

38) Yamada R S, Armas A, Goldman M, Lin PS . A scanning electron microscopic comparison of a high volume final flush with several irrigating solutions: part 3. J Endod 1983; 9: 137–142

39) Goldman M, Goldman L K B, Cavaleri R, Bogis J, Sun Lin P . The efficacy of several endodontic irrigating solutions: part 2. J Endod 1982; 8: 487–492.

40) Haapasalo M, Qian W, Shen Y . Irrigation: beyond the smear layer. Endodontic Topics 2012; 27: 35–53

41) Sen B H, Akdeniz B G, Denizci A A . The effect of ethylenediamine-tetraacetic acid on Candida albicans. Oral

Surg Oral Med Oral Pathol Oral Radiol Endod 2000; 90: 651–655

42) Ates M, Akdeniz B G, Sen B H . The effect of calcium chelating or binding agents on Candida albicans. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005; 100: 626–630

43) Stojicic S, Shen Y, Qian W, Johnson B, Haapasalo M . Antibacterial and smear layer removal ability of a novel irrigant, QMiX. Int Endod J 2012; 45: 363–371.

44) Haapasalo M, Qian W, Shen Y . Irrigation: beyond the smear layer. Endodontic Topics 2012; 27: 35–53

45) Sen B H, Akdeniz B G, Denizci A A . The effect of ethylenediamine-tetraacetic acid on Candida albicans. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000; 90: 651–655.

46) Ates M, Akdeniz B G, Sen B H . The effect of calcium chelating or binding agents on Candida albicans. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005; 100: 626–630.

47) Stojicic S, Shen Y, Qian W, Johnson B, Haapasalo M . Antibacterial and smear layer removal ability of a novel irrigant, QMiX. Int Endod J 2012; 45: 363–371.

48) Zehnder M, Schmidlin P, Sener B, Waltimo T . Chelation in root canal therapy reconsidered. J Endod 2005; 31: 817–820.

49) Torabinejad M, Khademi A A, Babagoli J et al. A new solution for the removal of the smear layer. J Endod 2003; 29: 175–170.

50) Torabinejad M, Cho Y, Khademi A A, Bakland L K, Shabahang S . The effect of various concentrations of sodium hypochlorite on the ability of MTAD to remove the smear layer. J Endod 2003; 29: 233–239

51) Shaker L A, Dancer B N, Russell A D et al. Emergence and development of chlorhexidine resistance during sporulation of Bacillus subtilis 168. FEMS Microbiol Lett 1988; 51: 73–76

52) Russell A D, Day M J . Antibacterial activity of chlorhexidine. J Hosp Infect 1993; 25: 229–238

53) Russell A D . Activity of biocides against mycobacteria. Soc Appl Bacteriol Symp Ser 1996; 25: 87S–101S

54) Vahdaty A, Pitt Ford T R, Wilson R F . Efficacy of chlorhexidine in disinfecting dentinal tubules in vitro. Endod Dent Traumatol 1993; 9: 243–248.

55)) Ng Y L, Mann V, Gulabivala K . A prospective study of the factors affecting outcomes of nonsurgical root canal treatment: part 1: periapical health. Int Endod J 2011; 44: 583–609.

56) Benjamin A. Nielsen, J. Craig Baumgartner. Comparison of the EndoVac System to Needle Irrigation of Root Canals J Endod 2007; 33(x)

57)Uroz-Torres D. Effectiveness of the EndoActivator System in removing the smear layer after root canal instrumentation. J Endod. 2010 Feb;36(2):308-11.

58)Rödig T. Comparison of the Vibringe system with syringe and passive ultrasonic irrigation in removing debris from simulated root canal irregularities. J Endod. 2010 Aug;36(8):1410-3

59) Rebecca Guidotti. Er:YAG 2,940-nm laser fiber in endodontic treatment: a help in removing smear layer. Lasers Med Sci (2014); 29(1):69-75

60)Meenu Saini. Comparative evaluation of the efficacy of three different irrigation devices in removal of debris from root canal at two different levels: An in vitro study. J Conserv Dent.2013NovDec;16(6):509-513

61)Guerreiro-Tanomaru JM. Effect of Passive Ultrasonic Irrigation on Enterococcus faecalis from Root Canals: An Ex Vivo Study. Braz Dent J. 2015 Jul-Aug;26(4):342-6.

62) Muhammad OH. Photodynamic therapy versus ultrasonic irrigation: interaction with endodontic microbial biofilm, an ex vivo study. Photodiagnosis Photodyn Ther. 2014 Jun;11(2):171

81-.

63) Manisha Laxmichand Kungwani. Comparison of the cleaning efficacy of EndoVac with conventional irrigation needles in debris removal from root canal. An in-vivo study.J Conserv Dent.2014 Jul-Aug;17(4):374-378

64)NBOAP Q+(„<!:!R", M" <11<A:3ISI(/M<4 I(T, -ADJUSTING FILE SYSTEM ON SMEAR LAYER: A SCANNING ELECTRON MICROSCOPY STUDY. Int Sch Res Notices 2014

65) Karatas E. Comparison of the effect of nonactivated self-adjusting file system, Vibringe, EndoVac, ultrasonic and needle irrigation on apical extrusion of debris. Int Endod J. 2015 Apr;48(4):317-22.

66) Elnaghy AM. Effectiveness of XP-endo Finisher, EndoActivator, and File agitation on debris and smear layer removal in curved root canals: a comparative study. Odontology. 2016 May.

67) Shinam Kapila Pasricha, Sameer Makkar, Pranav Gupta.Pressure Alteration Techniques in Endodontics- A Review of Literature J Clin Diagn Res.2015 Mar;9(3): ZE01-ZE06.

68) Max-i-Probe brochure by DENTSPLY.

69)NaviTip Delivery Tips brochure by Ultradent

70)Shinam Kapila Pasricha, Sameer Makkar, Pranav Gupta.Pressure Alteration Techniques in Endodontics- A Review of Literature J Clin Diagn Res.2015 Mar;9(3): ZE01-ZE06.

71)Eleni Protogerou et al.Effectiveness of a Canal Brush on Removing Smear Layer: A Scanning Electron Microscopic Study Braz Dent J (2013); 24(6): 580-584

72)Deenadayalan Elumalai et al. Newer Endodontic irrigation devices: An update. J Dent Med Sci2014) Jun; 13(6): 04-08.

73)Clifford J Ruddle. Endodontic disinfection tsunami irrigation.Saudi ENDOD J (2015);5(1):1-12.

74)Van der Sluis LW. Passive ultrasonic irrigation of the root canal: a review of the literature. Int Endod J. 2007 Jun;40(6):415-26.

75)Mozo S, Llena C, Forner L.Review of ultrasonic irrigation in endodontics: increasing action of irrigating solutions. Med Oral Patol Oral Cir Bucal. 2012 May ;17(3):512-6.

76)Shin SJ, Kim HK, Jung IY, Lee CY, Lee SJ, Kim E.Comparison of the cleaning efficacy of a new apical negative pressure irrigating system with conventional irrigation needles in the root canals. Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 2010Mar;109(3):479-84.

77)Nielsen BA, Baumgartner JC. Comparison of the endovac system to needle irrigationofrootcanals.JEndod.2007;33:611-5.

78)Hauser V, Braun A, Frentzen M. Penetration depth of a dye marker into dentine using a novel hydrodynamic system (RinsEndo). Int Endod J 2007;40:644-52.

79)Wiggins S, Ottino JM. Foundations of chaotic mixing. Philos Trans A Math Phys Eng Sci 2004;362:937- 70.

80)Burns T, Wilson M, Pearson GJ. Sensitisation of cariogenic bacteria to killing by light from a helium- neon laser. J Med Microbiol. 1993;38(6):401-405.

81)Schlafer S, Vaeth M, Horsted- Bindslev P, Frandsen EVG. Endodontic photoactivated disinfection using a conventional light source: an in vitro and ex vivo study. Oral Surg Oral Med Oral Pathol. 2010;109(4):634-64

82)Nagayoshi M, Fukuizumi T, Kitamura C, Yano J, Terashita M, Nishihara T. Efficacy of ozone on survival and permeability of oral microorganisms.Oral MicrobiolImmunol. 2004;19(4):240 6-.

83)Blanken J, De Moor RJG, Meire M, Verdaasdonk R. Laser induced explosive vapor and cavitation resulting in effective irrigation of the root canal. Part 1: A visualization study.Lasers Surg Med 2009;41(7):514-519.

84)Ercan E. Antibacterial activity of 2% chlorhexidine gluconate and 5.25% sodium hypochlorite in infected root canal: in vivo study. J Endod. 2004 Feb;30(2):84-7.

85)Takeda FH. A comparative study of the removal of smear layer by three endodontic irrigants and two types of laser. Int Endod J. 1999 Jan;32(1):32-9.

86) Marais JT. Antimicrobial effectiveness of electro-chemically activated water as an endodontic irrigation solution. Int Endod J. 2001 Apr;34(3):237-43.

87)Shabahang S. In vitro antimicrobial efficacy of MTAD and sodium hypochlorite. J Endod. 2003 Jul;29(7):450-2

88)Nagayoshi M. Antimicrobial effect of ozonated water on bacteria invading dentinal tubules. J Endod. 2004 Nov;30(11):778-81.

89)Khedmat S. Comparison of the efficacy of three chelating agents in smear layer removal. J Endod. 2008 May;34(5):599-602.

90)Giardino L. Antimicrobial effect of MTAD, Tetraclean, Cloreximid, and sodium hypochlorite on three common endodontic pathogens. Indian J Dent Res. 2009 Jul-Sep;20(3):391

91)Vinod B. Mathew, Koppolu Madhusudhana, Redderu K. Reddy. Anti-microbial efficiency of silver diamine fluoride as an endodontic medicament An ex vivo study. Contemp Clin Dent.2012 JulSep;3(3):262-264.

92)Hannah Rosaline. Influence of various herbal irrigants as a final rinse on the adherence of Enterococcus faecalis by fluorescence confocal laser scanning microscope.J Conserv Dent.2013 Jul-Aug;16(4):352-355