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IRRIGATION IN THE ENDODONTICS

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الاهداء

الى كل من أضاء بعلمه عقل غيره
او هدى بالجواب حيرة سائله
فأظهر بسماحة تواضع العلماء
وبرحابة سماحة العارفين....

أهدي هذا العمل المتواضع

الى أبي الذي لم يبخل علي يوما بشيء
والى أمي التي زودتني بالحنان والمحبة

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

{ وَأَخِرُ دَعْوَاهُمْ أَنْ الْحَمْدُ لِلَّهِ رَبِّ الْعَالَمِينَ }

صدق الله العلي العظيم

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1.Abstract:Successful root canal therapy relies on the combination of proper instrumentation, irrigation, and obturation of the root canal. Of these three essential steps of root canal therapy, irrigation of the root canal is the most important determinant in the healing of the periapical tissues. The primary endodontic treatment goal must thus be to optimize root canal disinfection and to prevent **reinfection.**(1)

Figure:1



2.INTRUDACTION :

Bacteria have long been recognized as the primary etiologic factors in the development of pulp and periapical lesions.[1–3] Successful root canal therapy depends on thorough chemomechanical debridement of pulpal tissue, dentin debris, and infective microorganisms. Irrigants can augment mechanical debridement by flushing out debris, dissolving tissue, and disinfecting the root canal system. Chemical debridement is especially needed for teeth with complex internal anatomy such as fins or other irregularities that might be missed by instrumentation(2)(3)(4)

Root canal treatment aims to prevent or cure apical periodontitis, and this aim is achieved by eliminating microorganisms capable of causing an intraradicular or extraradicular infection. It is well documented that mechanical instrumentation and strong antibacterial irrigation followed by well-sealed obturation of the root canal system can significantly reduce the bacterial load and create an environment conducive to healing. During endodontic disinfection, the clinician faces many limiting factors: such as complex root canal anatomy, untouched dentin walls left during mechanical instrumentation, and bacterial load in forms of biofilm attached to dentin walls and in the isthmus.(5)

3. Benefits of Using Irrigants in Root Canal Treatment

- ◆ Removal of particulate debris and wetting of the canal walls
- ◆ Destruction of microorganisms
- ◆ Dissolution of organic debris
- ◆ Opening of dentinal tubules by removal of the smear layer
- ◆ Disinfection and cleaning of areas inaccessible to endodontic instruments(6)

4. Properties of an Ideal Irrigant for Root Canal Treatment

An ideal irrigant should do the following:

- ◆ Be an effective germicide and fungicide
- ◆ Be nonirritating to the periapical tissues
- ◆ Remain stable in solution
- ◆ Have a prolonged antimicrobial effect
- ◆ Be active in the presence of blood, serum, and protein derivatives of tissue
- ◆ Have low surface tension
- ◆ Not interfere with repair of periapical tissues
- ◆ Not stain tooth structure
- ◆ Be capable of inactivation in a culture medium
- ◆ Not induce a cell-mediated immune response
- ◆ Be able to completely remove the smear layer, and be able to disinfect the underlying dentin and its tubules
- ◆ Be nonantigenic, nontoxic, and noncarcinogenic to tissue cells surrounding the tooth
- ◆ Have no adverse effects on the physical properties of exposed dentin
- ◆ Have no adverse effects on the sealing ability of filling materials
- ◆ Have a convenient application
- ◆ Be relatively inexpensive(7)

5. DISINFECTION OF THE ROOT CANAL SYSTEM

Hydrodynamics of Irrigation Irrigation dynamics refers to how irrigants flow, penetrate, and readily exchange within the root canal system as well as the forces they produce. A better understanding of the fluid dynamics of different modes of irrigation will contribute to achieving predictable disinfection of the root canal system. Hence, in endodontic disinfection, the process of delivery is as important as the antibacterial characteristics of the irrigants. Irrigation is defined as “to wash out a body cavity or wound with water or a medicated fluid” and aspiration as “the process of removing fluids or gases from the body with a suction device.” Disinfectant, meanwhile, is defined as “an agent that destroys or inhibits the activity of microorganisms that cause disease. The objectives of irrigation in endodontics are mechanical, chemical, and biologic.

The mechanical and chemical objectives are as follows: (1) flush out debris

- (2) lubricate the canal,
- (3) dissolve organic and inorganic tissue, and
- (4) prevent the formation of a smear layer during instrumentation or dissolve it once it has formed.

The mechanical effectiveness will depend on the ability of irrigation to generate optimum streaming forces within the entire root-canal system.

The chemical effectiveness will depend on the concentration of the antimicrobial irrigant, the area of contact, and the duration of interaction between irrigant and infected material. The final efficiency of endodontic disinfection will depend on its

chemical and mechanical effectiveness. The biologic function of irrigants is related to their antimicrobial effects. In principle, irrigants should

- (1) have a high efficacy against anaerobic and facultative microorganisms in their planktonic state and in biofilms,
- (2) inactivate(8)

6.main requirements for root canal irrigants are as follows:

Strong antimicrobial action against a broad spectrum of microorganisms, both planktonic and those organized in biofilms
Inactivation of bacterial virulence factors, such as endotoxins and lipoteichoic acids
Disruption or removal of the biofilm
Dissolution of pulp tissue remnants
Removal of accumulated hard-tissue debris and the smear layer or prevention of their formation
Lack of adverse effects, both local (on dentine and the periapical tissues) and systemic (toxicity, allergic reactions)
Wide availability at low cost

the most important requirements for effective irrigation are that the irrigant must reach the biofilm and act against it physically and chemically. Therefore, it is imperative that future laboratory studies focus primarily on irrigant penetration and its anti-biofilm effect, particularly in teeth with multiple root canals and complex anatomy. The development of new irrigants and their optimum clinical use will benefit greatly from advances in the bacteria sampling and detection methods and a deeper understanding of biofilm physiology and biofilm–host interactions. The most promising irrigants and irrigation methods should be further tested in clinical trials focusing on the healing of apical periodontitis **(9)**

7. Needle tip size and designs

There are different sizes and types of irrigation needles. The size of the irrigation needle should be chosen depending on the canal size and taper. Most root canals that have not been instrumented are too narrow to be reached effectively by disinfectants, even when fine irrigation needles are used (see Figs. 2 and 3). Therefore, effective cleaning of the root canal must include intermittent agitation of the canal content with a small instrument to prevent debris from accumulating at the apical portion of the root canal (see figure.4). Preparation size and taper ultimately determine how close a needle can be placed to the final apical millimeters of a root canal. Open-ended needles are recommended over the end open needles to prevent extrusion of the irrigant. Some needles and suction tips may be attached to the air/water syringe to increase both the speed of irrigant flow and the volume of irrigant. Examples include the Stropko Irrigator (Vista Dental Products), which is an adapter that connects to the air/water syringe and accepts standard Luer-lock needle tips for irrigant removal and application as well as air-drying (10). Therefore, the choice of an appropriate irrigating needle is important. Although larger-gauge needles allow a quicker and larger amount of fluid exchange, the wider diameter does not allow cleaning of the apical and narrower areas of the root canal system (11).

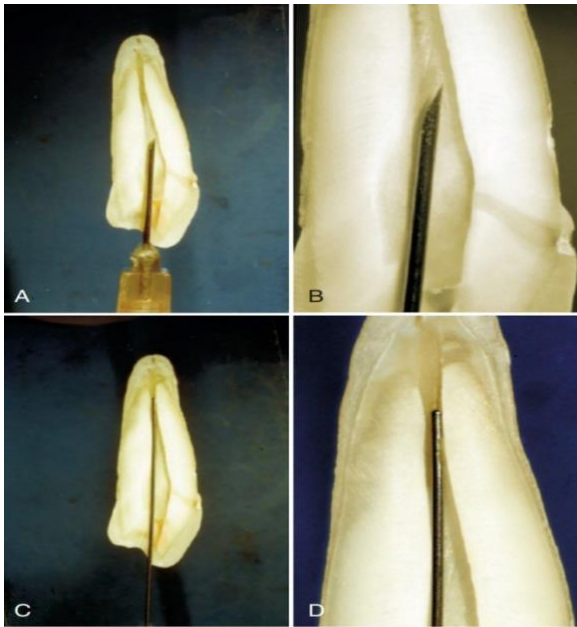


Figure (2)

Fig.2 Irrigation needles inserted into prepared root canals. A-B, A 27-gauge needle barely reaches the middle third. C-D, A 30-gauge, side-venting needle reaches the apical third in adequately enlarged canals.

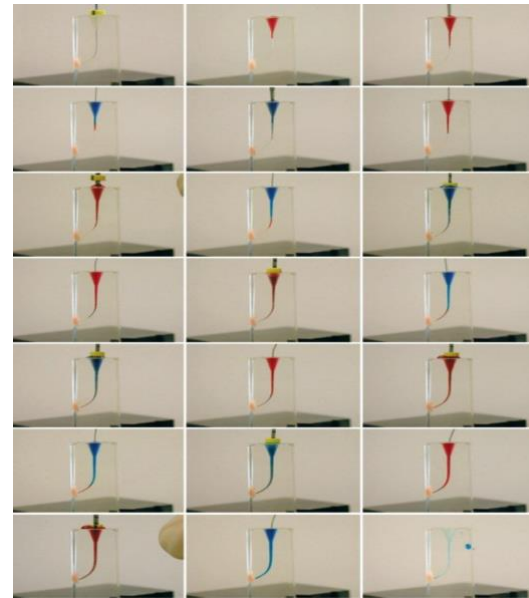
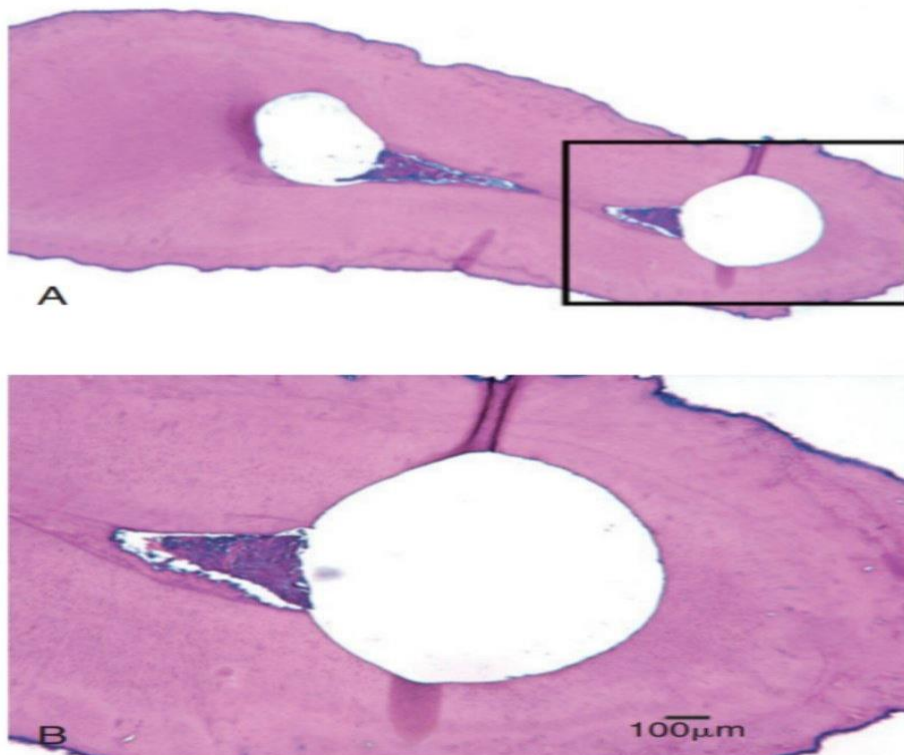


Figure (3)

Fig.3 Irrigation and movement of irrigants depends on canal shape. Sequential enlargement of a canal in clear plastic block was performed with a sequence of Profile instruments in accordance with the manufacturer's recommendations. Alternating irrigation with blue and red fluid was done after each preparation step. Note the apical presence of irrigant after sufficient shape has been provided. Note the distribution of fluid immediately after irrigation with a 30-gauge needle

Fig.4 Remaining potentially infected tissue in fins and isthmus configuration after preparation with rotary instruments. A, Cross section through a mesial root of a mandibular molar, middle to coronal third of the root. Both canals have been shaped, the left one is transported mesially (x10). B. Magnified view of rectangle in A. Note the presence of soft tissue in the isthmus area (x63). (Courtesy Professor H. Messer.)



8. Endodontic irrigation solution

A. Endodontic

irrigants

Non-bactericidal irrigants Some general dental practitioners either use saline, local anaesthetics and/or distilled water. These have no antibacterial action and will not reduce bacterial load significantly. These irrigants may be used frequently as they are easy to use and readily available. In the case of local anaesthetic solutions, they also come in sterile packaging and can be dispensed easily through very small gauge needles. Additional contributing factors for their use may be safety. These irrigants should have no role in managing infected root canals. There are a number of better irrigating solutions available which are more appropriate for managing infected root canals

B. Bacteriostatic/bactericidal irrigants

These include an array of solutions which either kill bacteria or facilitate their death by allowing other irrigants to come into contact with the bacteria (12)

8.1_Sodiumhypochlorite

Sodium hypochlorite (NaOCl) is the most frequently recommended and a commonly used endodontic irrigant. Its advantages are two-fold; pulpal dissolution and antimicrobial effect. NaOCl is a strong base (pH>11) and acts as an organic solvent, causing amino acid degradation and hydrolysis through the production of chloramine molecules. There is evidence to show that a decrease in microbial numbers is achievable when using NaOCl for endodontic treatment of teeth with apical periodontitis. The smear layer is not removed by NaOCl. NaOCl is available from a variety of sources from supermarkets to dental supply companies and in a variety of concentrations. When NaOCl is chosen, it must be remembered that the concentration and temperature of the solution has a bearing on its effectiveness. A concentration of over 0.5% is required to reduce bacterial load significantly. In vitro evidence has implied that using NaOCl at a concentration of 0.5% for 10 seconds can reduce the bacterial load of *A. naeslundii* (found in untreated necrotic root canals) and *C. albicans* (found in endodontic failure cases) to below the limit of detection. It was seen that a contact period of 30 minutes was required to reduce the bacterial load of *E. faecalis* below the limit of detection. At a concentration of 5.25%, 2 minutes of contact was required to reduce the bacterial load. Other studies have shown that a concentration of 5.25% NaOCl can kill *E. faecalis* and *C. albicans* within 15–30 seconds. NaOCl, at a concentration of 1% heated to 20°C, is less effective than that at 45°C, which in turn is less effective than that at 60°C, as more chlorine is released at higher temperatures. NaOCl at a concentration of 5.25% heated to 20°C is as effective as NaOCl at a concentration of 1% heated to 45°C. NaOCl at a concentration

of 1% heated to 60°C is significantly more effective than 5.25% at 20°C. (15) The same study showed that aqueous solutions of 1%, 2.62% and 5.25% NaOCl heated to 21°C, 45°C and 60°C maintained 100% availability of chlorine for at least 60 minutes. Stock solutions should be stored at low temperatures and heated chair-side when required. To achieve pulpal dissolution a concentration of 1% or above is required. There is limited evidence for NaOCl at a concentration of 6% being significantly better than 5.25%. However, common sense dictates that higher concentrations will achieve reduction in bacterial load faster owing to the presence of a higher concentration of chloramine molecules. It should also be kept in mind that the more concentrated solutions of NaOCl are thicker and subsequently there is less wetting of the canal walls. It has been observed that NaOCl solutions at concentrations of 0.5%, 3% and 5% degrade the organic phase (collagen) of dentine with no loss of mineral, possibly leading to brittleness of endodontically treated teeth. There are significant biological toxicity risks if NaOCl is expressed under pressure into the periodontal ligament space. The outcomes are significantly worse the higher the concentration. The advantage of lower concentrations of NaOCl heated to higher temperatures is that, once they reach body temperature, the systemic toxicity should be lower than that of nonheated, high concentrations of NaOCl. (13)

8.2_Iodine

Iodine was introduced into endodontics in 1979 advocating the use of povidone iodine, as it was seen to be an antiseptic against a broad range of micro-organisms, hypoallergenic, with low toxicity and has a decreased tendency to stain

dentine. Since then iodine has been shown to be bactericidal, fungicidal, tuberculocidal, virucidal and sporicidal. The collagen matrix in dentine can inhibit iodine. It is thought that iodine attacks key group proteins, nucleotides and fatty acids, leading to cell death. The advantage of iodine over the other irrigants is that 2% preparations of Iodine Potassium Iodide (IPI) used in endodontics are shown to be less irritating and toxic than Formocresol, Camphorated Monochlorophenol (FMCP), and Cresatin. (2,17) It is also suggested that iodine at a concentration of 2% is faster at reducing the bacterial load than a calcium hydroxide inter-appointment dressing; 2%IPI needs 1–2 hours to prevent growth of *E. faecalis*. (13)

8.3_EDTA

Ethylenediaminetetraacetic acid (EDTA) is a synthetic amino acid and the sodium salts of EDTA (Na₂EDTA) are used in dentistry. It is often used as a chelating agent (substances with an ability to scavenge up and form ring-shaped internal complexes with metallic ions including calcium) and is non corrosive to instruments. EDTA is not bactericidal nor bacteriostatic but inhibits the growth of, and eventually kills, bacteria by starvation as metallic ions needed for growth are chelated thus are not available for use by micro-organisms. EDTA is relatively non toxic but is slightly irritating in weak solution. EDTA at concentrations of 15–17% removes calcium from dentine leaving a softened matrix of dentine. It also emulsifies soft tissue and removes the smear layer with no deleterious effect to pulpal or periapical tissues. The application of EDTA at a concentration of 17% for over 10 minutes has been shown to cause excessive erosion of peritubular and intertubular dentine. The suggestion is for EDTA to be in the root canal system 1–5 minutes to achieve the desired effect. EDTA, like many other irrigants, is self limiting. (13)

8.4_Hydrogenperoxide

Hydrogen peroxide (H₂O₂) is a colourless liquid and has been used in dentistry in concentrations varying from 1% to 30%. H₂O₂ degrades to form water and oxygen. It is active against viruses, bacteria, bacterial spores and yeasts via the production of hydroxyl free radicals which attack proteins and DNA. It has been shown that NaOCl, combined with H₂O₂, is no more effective against *E. faecalis* than NaOCl alone; (8) however, CHX

combined with H₂O₂ was a better antimicrobial agent than either one on their own. The current evidence does not support the use of H₂O₂ over other irrigants and it has not been shown to reduce bacterial load in canals significantly. There is the rare but potential danger of effervescence with H₂O₂ and seepage into the tissues may lead to air emphysema. (13)

Summary

Sodium hypochlorite is still the most effective 'gold standard irrigant'. Unlike with sodium hypochlorite, the extrusion of iodine and chlorhexidine is thought to be more forgiving to the soft tissues as they do not dissolve organic tissue. Chelators in liquid form are not a replacement for antimicrobial irrigants like NaOCl. The antimicrobial properties of chelators are low yet they can be used to remove the smear layer, increasing the penetration of other irrigants such as NaOCl and hence increasing their antimicrobial effects. The inorganic portion of smear layer can be removed by the use of 15–17% concentrations of EDTA and the organic portion can be removed by NaOCl in concentrations exceeding 1%. Chelators in paste form can act as lubricants and may reduce the risk of instrument separation. Local anaesthetic agents and saline have no antimicrobial properties. These are useful only as a flushing agent in non-infected teeth (ie irreversible pulpitis cases and elective endodontic treatment). They cannot be expected to remove and kill microbes within the root canal system. They are also more expensive to purchase than sodium hypochlorite. Dentine has a buffering capacity and is able to neutralize acids and alkalines. The organic part of dentine is able to reduce the antimicrobial effect of chlorhexidine, iodine potassium iodide, and sodium hypochlorite. As yet there is limited evidence of methods to overcome this problem. (13)

9. Irrigants Activation Techniques

Using a conventional syringe for irrigation is the most prevalent method used for clinical practice. It implies a variety of problems including the vapor lock effect and a lower disinfection level of up to one-third of the apical portion of the root canal . The shape of the needle used with a syringe in irrigation may also modulate the flow of the irrigant within a canal, thereby influencing the efficacy of the process. In general, needles can be classified as closed-ended or open-ended. The latter is described as more effective but increases the danger of irrigant extrusion through the apical foramen . The computational fluid dynamics may differ based on the type of needle. It may be validated using micro-particle image velocimetry measurements . The literature reports that activation of irrigants led to more efficient smear layer cleansing in comparison with the same liquids without activation . Moreover, it was reported that activation of sodium hypochlorite improves its capability of dissolving organic tissue . Irrigants need to have direct contact with the root canal's wall in order to act effectively. During conventional irrigation with a needle, the exchange of fluids occurs only in very close proximity around the needle's tip (approximately 1.00–1.15 mm according to the studies) This is a reason why syringe irrigation should only be used when it can be inserted within 1 mm of the working length. It is not always possible due to the complicated morphology of root canals and the danger of forcing the solution through the tissues The velocity of liquid administration is a factor directly influencing flow outside of the needle. Between operators, a broad distribution of the aforementioned parameter was observed. It makes the syringe irrigation challenging to standardize and contro (14)

10. TYPES OF IRRIGATION AGITATION

TECHNIQUES AND DEVICE:

10. 1)MANUAL AGITATION TECHNIQUES

10.1.1)Syringe irrigation with
needle/cannulas

10.1.2)Brushes

10.1.3)Manual dynamic agitation

10. 2)MACHINE ASSISTED TECHNIQUE

10.2.1)Rotary brushes

10.2.2)Continuous irrigation during rotary instrumentation

10.2.3)Sonic irrigation

10.2.4)Ultrasonic irrigation technique

10.2.5)Continuous

10.2.6)Passive

10.2.7)Pressure alternation devices

10.2.8)Endo vac system

10.2.9)Rins Endo system

10.2.10)Photo Activated Disinfection

10.2.11)Ozone based delivery system

10.2.12)Laser

10. 1)MANUAL AGITATION TECHNIQUE:The simplest of all mechanical activation techniques is the manual irrigant agitation, which can be performed with different systems. The easiest way to achieve this effect is moving vertically and passively the endodontic file within the root canal. The file promotes the irrigant penetration⁸ and reduces the presence of air bubbles in the canal space⁹ ,but does not improve the final cleaning **(15)**

10.1_1)

SYRINGE

IRRIGATION

WITH NEEDLES/CANNULAS. 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. 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. Irrigation tip gauge will largely determine how deep an irrigant can penetrate into the canal. A 21-gauge tip can reach the apex of an ISO size 80 canal, a 23-gauge tip can reach a size 50, a 25-gauge tip can reach a size 35 canal, and a 30-gauge tip can reach the apex of a size 25 canal. 27 gauge needle is the preferred needle tip size for routine endodontic procedures¹¹, Open-ended tips express irrigant out the end toward the apex and consequently increase the apical pressure within the canal. Closed-ended irrigant tips 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 (16)

Figur(5)



10.1 _2)ROTARY BRUSHES:Brushes are not directly used for delivering an irrigant into the canal spaces. They are adjuncts that have been designed for debridement of the canal walls or agitation of root canal irrigant irrigation needle covered with a brush was introduced commercially by Ultradent company^{17,18} The Endobrush could not be used to full working length because of its size, which might lead to packing of debris into the apical section of the canal after brushing (19)

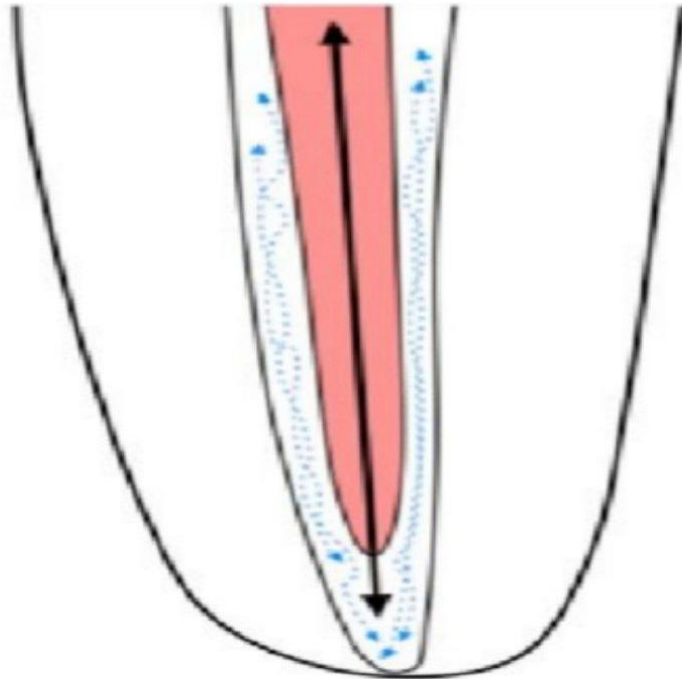
Figure (6)



10.1_3)MANUAL DYNAMIC AGITATION:Manual dynamic agitation (MDA) has been described as a simple and cost-effective technique for activation of the irrigant. It involves repeated insertion of a well-fitting gutta-percha cone to the working length of a previously

An irrigant must be in direct contact with the canal walls for effective action. Its often difficult for the irrigant to reach the apical portion of the canal because of the so-called vapor lock effect^{20,21}. The 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



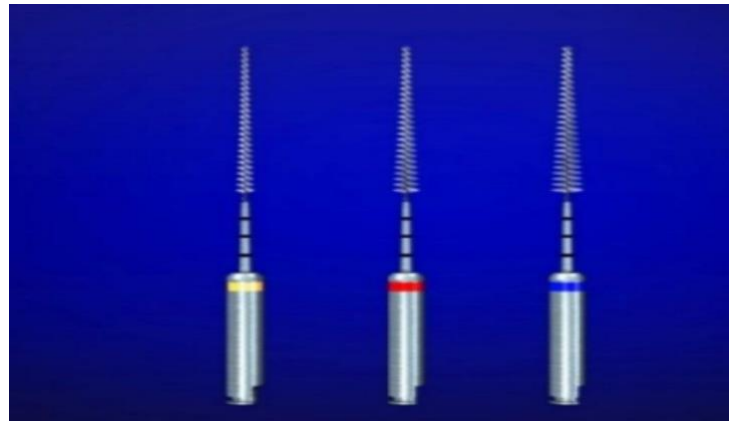
reagent(22) Figure (7).

10.2) MACHINE ASSISTED AGITATION TECHNIQUE:The evolution of the manual systems led to the introduction of instruments that may be rotated by handpieces at low speed inside the canal fill with irrigant. Instruments such as plastic files can show a smooth surface and increased taper , or even a surface with lateral plastic extensions 23.24

10.2_1) ROTARY BRUSHES:Ruddle brush and canal brush come under this.

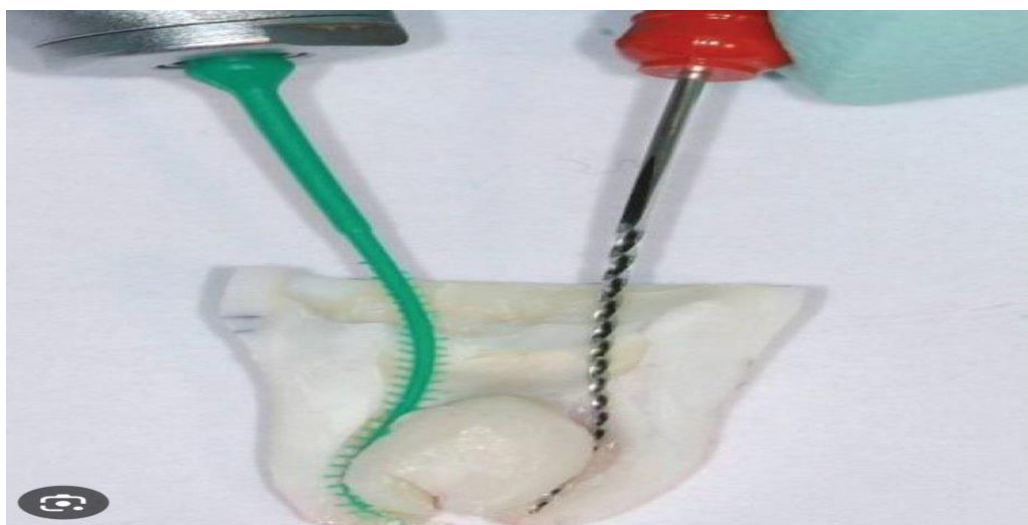
10.2_1_i) A rotary handpiece-attached microbrush has been used by ruddle to facilitate debris and smear layer removal from instrumented root canal. The brush includes a shaft or shank and a tapered brush section. During debridement phase, microbrush rotates at about 300 rpm. These brushes are not straightly used for delivering an irrigant into the canal

spaces. They are adjuncts that has been planned for agitation



of root canal irrigation.(25) Figure (8)

10.2_1. ii) Canal Brush is another endodontic microbrush that has recently been made commercially available. This highly flexible microbrush is molded entirely from polypropylene and might be used manually with a rotary action. Weise et al., showed that debris was effectively removed from simulated canal extensions and irregularities with the use of the small and flexible CanalBrush with an irrigant Figure (9)



10.2_2)CONTINUOUS IRRIGATION DURING ROTARY IRRIGATION:

10.2_2(i) The Quantec-E irrigation system (Sybron Endo, Orange, CA) is a self contained fluid delivery unit which is attached to the Quantec-E Endo System . It consist of a pump console, two irrigation reservoirs, and tubing which provide continuous irrigation during rotary instrumentation²⁶.Continuous irrigant agitation during active rotary instrumentation would result in generation of 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 in comparision with syringe needle irrigation. Studies conducted by Setlock et al and Walters et al concluded that Quantec - E irrigation did result in cleaner canal walls and more complete debris and smear layer removal in the coronal third of the canal walls⁽²⁷⁾ Figure (10)



figure (11)



10._2_3) SONIC IRRIGATION: Sonic instruments was introduced by Tronstad et al in 1985. It works in lower frequency (1–6 kHz) and produces smaller shear stresses than ultrasonic irrigation. There are several sonic irrigation devices on the market³⁴ Vibringe system is the first endodontic sonic irrigation system that permits the delivery and activation of the irrigation solution in the root canal. The activation of the disinfectant by acoustic streaming enhances and completes the irrigation procedure and upgrade the success rate of endodontic treatments. It improves the debridement and disrupts the smear layer ³⁵.It has better irrigation than the syringe irrigation in removing the debris from the apical two third of the rootcanal



figure (12)

Endo activator is a mechanical system which consists of a hand piece and various polymer tips. These tips are strong and flexible and do not break easily. They are smooth and they do not cut the dentin. It removes the smear layer, debrides the uninstrumented portion of the root canal system, and dislodges the biofilm within long, narrow, and highly curved canals of molar teeth. It provides 10,000 cpm



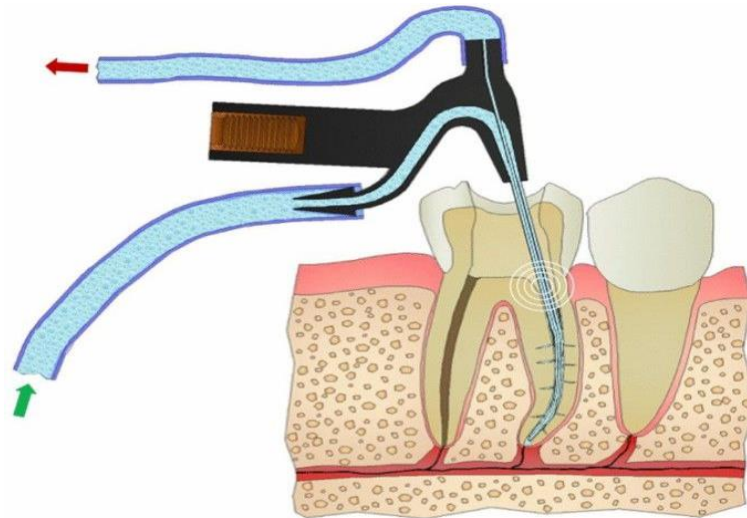
per minute^{36,37,38}

Figure (13)

10.2_4)ULTRASONIC IRRIGATION: Ultrasonic energy produces higher frequencies than sonic energy but has low amplitudes, oscillating at frequencies of 25- 30 kHz^{39,40}. Two types of ultrasonic irrigation are present one is simultaneous ultrasonic instrumentation and irrigation (UI) and the other one is passive ultrasonic irrigation (PUI), operates without simultaneous instrumentation⁽⁴¹⁾

10.2_4_i)CONTINUOUS ULTRASONIC IRRIGATION: Nusstein introduced 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 needle is activated simultaneously by the ultrasonic handpiece, while an irrigant is carried out from intravenous tubing connected via a

Luer-lok to an irrigation- delivering syringe. Irrigant is delivered



in apical one third by continuous flow (42)(43)

Figure (14)

10.2_4_ii) PASSIVE ULTRASONIC IRRIGATION: The term passive ultrasonic irrigation was given by Weller et al in the year 1980³⁷. It is non cutting technology which reduces creating abnormal shapes in root canal system. During PUI, energy is transmitted from a file or smooth oscillating wire to the irrigant by means of ultrasonic waves that induce two physical phenomena: stream and cavitation of the irrigant solution. The acoustic stream can be defined as a rapid movement of the fluid in a circular or vortex shape around the vibrating file. Cavitation is defined as the creation of steam bubbles or the expansion, contraction and/or distortion of pre-existing bubbles in a liquid (44). The main goal of this treatment is to remove the pulp tissues, dentinal debris, smear layer and bacteria from the root canal

10.2_5)PRESSURE ALTERATION DEVICES: 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 foramen 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 problem(45)

A)ENDO VAC 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 55 open end with a .02 taper and is attached to a titanium handle 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 irrigant from its fresh supply in the chamber, 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(46)(47)

Figure (15)

B)RINS ENDO SYSTEM: Rins Endo was introduced by Durr Dental Co. its based on pressure suction technology with approximately 100 cycles per minute(48). Its components are a handpiece, a cannula with a 7 mm exit aperture, and a syringe carrying irrigant. The 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(49)



RinsEndo

Figure (16)

10.2_6)PHOTO ACTIVATED DISINFECTION: 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 (51)(52) 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 (O₂), which is transformed into highly reactive oxygen species (ROS), such as oxygen ions and radicals(53)

Figure (17)



10.2_7) 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 (O₂), thus liberating so-called singlet oxygen (O¹), 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(54)

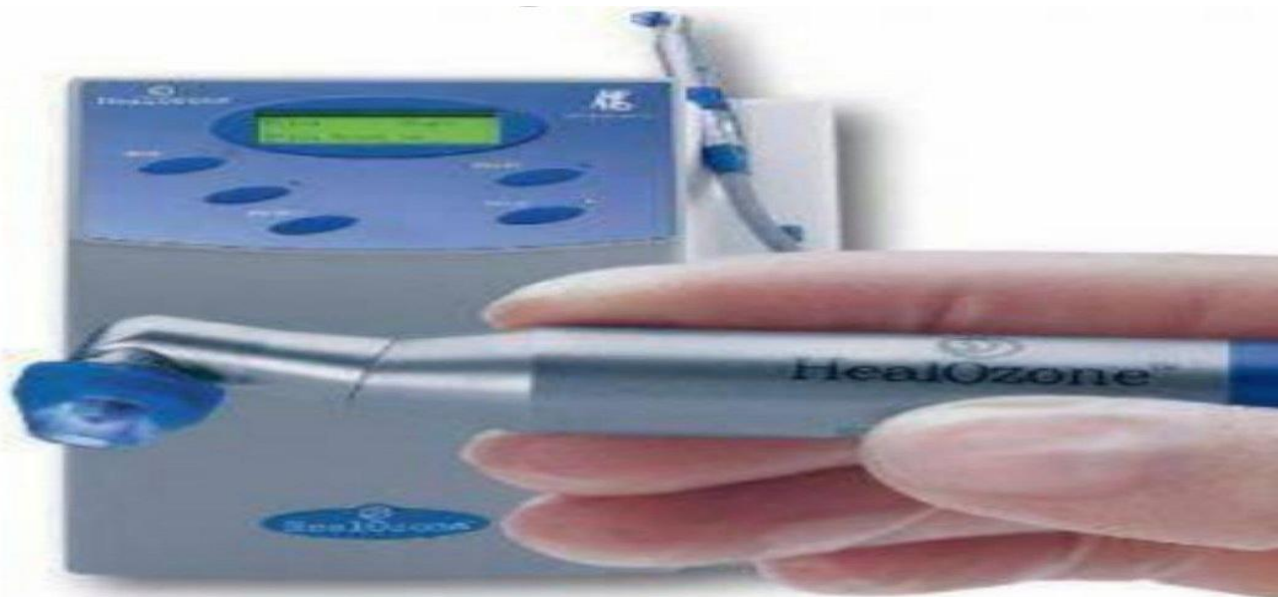
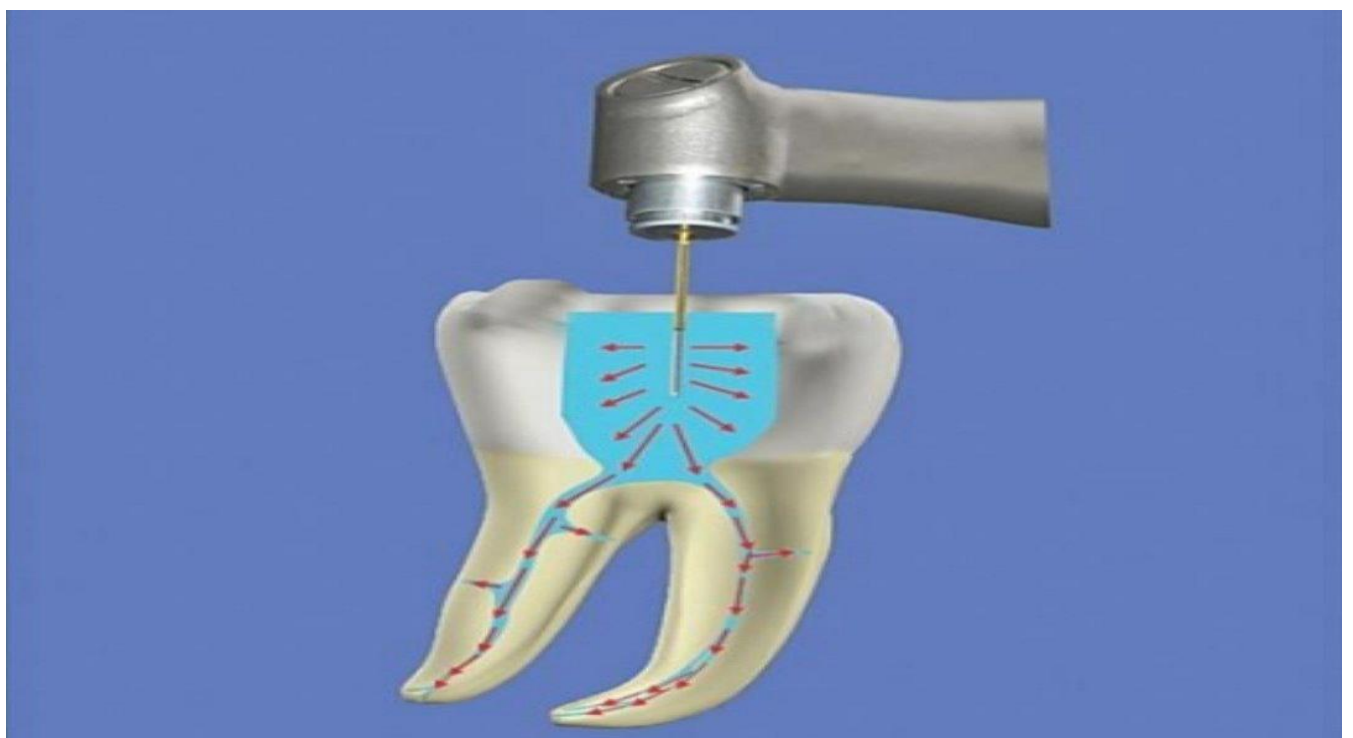


Figure (18)

10.2_8)LASER: Lasers have been recently proposed to activate irrigation solutions by the transfer of pulsed energy(55)(56) 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(57)(58) . 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(59)(60) . In conclusion, there is still no strong evidence to support the application of high-power lasers for direct disinfection of root canals(61)(62) Figure (19)



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. Grossman LI, Meiman BW. Solution of pulp tissue by chemical agents. *J Am Dent Assoc.* 1941;28: 223–225.
- 2.3. 4. Kakehashi S, Stanley HR, Fitzgerald RJ. The effects of surgical exposures of dental pulps in germ-free and conventional laboratory rats. *Oral Surg Oral Med Oral Pathol.* 1965;20:340–9. [PubMed]
5. Grossman LI, Meiman BW. Solution of pulp tissue by chemical agents. *J Am Dent Assoc.* 1941;28: 223–225.
- 6.7.8. Cohen pathways of the pulp (PDFDrive)
9. Cohen pathways of the pulp (PDFDrive)
- 10.11. Cohen pathways of the pulp (PDFDrive)
12. Torabinejad M, Khademi AA, Babagoli J, Cho Y, Johnson WB, Bozhilov K, Kim J, Shabahang S. A new solution for the removal of the smear layer. *J Endod.* 2003;29:170–175. [PubMed]
- 12.. Beltz RE, Torabinejad M, Pouresmail M. Quantitative analysis of the solubilising action of MTAD, sodium hypochlorite and EDTA on bovine pulp and dentine. *J Endod.* 2003;29:334–337. [PubMed]
- 12.. Zhang W, Torabinejad M, Li Y. Evaluation of cytotoxicity of MTAD using the MTT-tetrazolium method. *J Endod.* 2003;29:654–657. [PubMed]
13. Zhang W, Torabinejad M, Li Y. Evaluation of cytotoxicity of MTAD using the MTT-tetrazolium method. *J Endod.* 2003;29:654–657. [PubMed] Shabahang S, Pouresmail M, Torabinejad M. In vitro antimicrobial efficacy of MTAD and sodium. *J Endod.* 2003;29:450–452. [PubMed]. Shabahang S, Torabinejad M. Effect of MTAD on *Enterococcus faecalis* contaminated root canals of extracted human teeth. *J Endod.* 2003;29:576. Bergmans L, Moisiadis P, Teughels W, Van Meerbeek B, Quirynen M, Lambrechts P. Bactericidal effect of Nd:YAG laser irradiation on some endodontic pathogens ex vivo. *Int Endodont J.* 2006;39:1–11. [PubMed]
13. Gulabivala K, Stock CJR, Lewsey JD, Ghorri S, Ng Y-L, Spratt DA. Effectiveness of electrochemically activated water as an irrigant in an infected tooth model. *Int Endodont J.* 2004;37:624–631. [PubMed]
14. Dioguardi, M.; Di Gioia, G.; Illuzzi, G.; Laneve, E.; Cocco, A.; Troiano, G. Endodontic Irrigants: Different Methods to Improve Efficacy and Related Problems. *Eur. J. Dent.* 2018, 12, 459–466.
- Teixeira, C.S.; Felipe, M.C.S.; Felipe, W.T. The Effect of Application Time of EDTA and NaOCl on Intracanal Smear Layer Removal: An SEM Analysis. *Int. Endod. J.* 2005, 38, 285–290.
- Boutsioukis, C.; Arias-Moliz, M.T. Present Status and Future Directions—Irrigants and Irrigation Methods. *Int. Endod. J.* 2022, 55, 588–612.

- Rito Pereira, M.; Silva, G.; Semiao, V.; Silverio, V.; Martins, J.N.R.; Pascoal-Faria, P.; Alves, N.; Dias, J.R.; Ginjeira, A. Experimental Validation of a Computational Fluid Dynamics Model Using Micro-Particle Image Velocimetry of the Irrigation Flow in Confluent Canals. *Int. Endod. J.* 2022, 55, 1394–1403.
- Pladisai, P.; Ampornaramveth, R.S.; Chivatxaranukul, P. Effectiveness of Different Disinfection Protocols on the Reduction of Bacteria in *Enterococcus Faecalis* Biofilm in Teeth with Large Root Canals. *J. Endod.* 2016, 42, 460–464.
- Stojicic, S.; Zivkovic, S.; Qian, W.; Zhang, H.; Haapasalo, M. Tissue Dissolution by Sodium Hypochlorite: Effect of Concentration, Temperature, Agitation, and Surfactant. *J. Endod.* 2010, 36, 1558–1562.
- Boutsioukis, C.; Lambrianidis, T.; Kastrinakis, E. Irrigant Flow within a Prepared Root Canal Using Various Flow Rates: A Computational Fluid Dynamics Study. *Int. Endod. J.* 2009, 42, 144–155.
- Abou-Rass, M.; Piccinino, M. V The Effectiveness of Four Clinical Irrigation Methods on the Removal of Root Canal Debris. *Oral Surg. Oral Med. Oral Pathol.* 1982, 54, 323–328.
- Boutsioukis, C.; Lambrianidis, T.; Kastrinakis, E.; Bekiaroglou, P. Measurement of Pressure and Flow Rates during Irrigation of a Root Canal Ex Vivo with Three Endodontic Needles. *Int. Endod. J.* 2007, 40, 504–513.
- 15.Paragliola R, Franco V, Fabiani C, Mazzone A, Nato F, Tay FR, et al.. Final rinse optimization: influence of different agitation protocols. *J Endod* 2010;36:282-285.
- 16.Sedgley CM, Nagel AC, Hall D, Applegate B. Influence of irrigant needle depth in removing bioluminescent bacteria inoculated into instrumented root canals using real-time imaging in vitro. *Int Endod J* 2005;38:97-104.
- 17.Keir DM, Senia ES, Montgomery S. Effectiveness of a brush in removing postinstrumentation canal debris. *J Endod* 1990;16:323–7.
- 18.Markus Haapasalo, et al., Irrigation in Endodontics. *Dent Clin N Am.* 2010;54:291–312.
19. Migun NP, Azuni MA. Filling of one-side-closed capillaries immersed in liquids. *J Colloid Interface Sci.* 1996;181:337–40.
- 20.21.. Al-Jadaa A, Paqué F, Attin T, Zehnder M. Acoustic hypochlorite activation in simulated curved canals. *J Endod* 2009 Oct;35(10):1408-1411.
- 22.Ruddle CJ. Microbrush for endodontic use. Washington, DC: United States Patent 6,179,617; 2001.
- 23.Al-Ali M, Sathorn C, Parashos P. Root canal debridement efficacy of different final irrigation protocols. *Int Endod J* 2012;45:898-906.

24. Garip Y, Sazak H, Gunday M, Hatipoglu S. Evaluation of smear layer removal after use of a canal brush: an SEM study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;110:e62-e66.
25. Tronstad L, Barnett F, Schwartzben L, Frasca P. Effectiveness and safety of a sonic vibratory endodontic instrument. *Endod Dent Traumatol.* 1985;1:69–76.
26. Pasricha SK, Makkar S, Gupta P. Pressure Alteration Techniques in Endodontics - A Review of Literature. *J Clin Diagn Res* 2015;9: ZE01-ZE06.
27. Walters MJ, Baumgartner JC, Marshall JG. Efficacy of irrigation with rotary instrumentation. *J Endod* 2002;28:837-9.
28. Walters MJ, Baumgartner JC, Marshall JG. Efficacy of irrigation with rotary instrumentation. *J Endod* 2002;28:837-9.
29. Metzger Z. From files to SAF:3D endodontic treatment is possible at last. *Alpha Omegan* 2011;104:36-44.
30. Ahmad M, Pitt Ford TR, Crum LA. Ultrasonic debridement of rootcanals: an insight into the mechanisms involved. *J Endod.* 1987;13:93-101.
31. Walters MJ, Baumgartner JC, Marshall JG. Efficacy of irrigation with rotary instrumentation. *J Endod* 2002;28:837–9.
32. Elumalai D, Kumar A, Tewari R K, Mishra S K, Iftexhar H, Alam S, Andrabi M Newer endodontic irrigation devices:an update. *Journal of Dental and Medical Sciences* 2014,Volume 13, Issue 6.
33. Ruddle CJ: Endodontic disinfection: tsunami irrigation, *Endodontic Practice* 11:1, pp. 7-15, 2008.
34. Kanter V, Weldon E, Nair U, Varella C, Kanter K, Anusavice K, Pileggi R: A quantitative and qualitative analysis of ultrasonic versus sonic endodontic systems on canal cleanliness and obturation, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 112:6, pp. 809-813,2011.
35. Caron, G, Nham K, Bronnec F, Machtou P: Effectiveness of different final irrigant protocols on smear layer removal in curved canals, *J Endod* 36:8, pp. 1361- 1366, 2010.
- 36.. Gu LS, Kim JR, Ling J, Choi KK, Pashley DH, Tay FR. Review of contemporary irrigant agitation techniques and devices. *J Endod.* 2009;35(6):791-804.
37. Walmsley AD, Williams AR. Effects of constraint on the oscillatory pattern of endosonic files. *J Endod.* 1989;15:189-94.

38. Cunningham WT, Martin H. A scanning electron microscope evaluation of root canal debridement with the endosonic ultrasonic synergistic system. *Oral Surg Oral Med Oral Pathol* 1982;53:527–31.
39. Gutarts R, Nusstein J, Reader A, Beck M. In vivo debridement efficacy of ultrasonic irrigation following hand-rotary instrumentation in human mandibular molars. *J Endod* 2005;31:166–70.
40. Burleson A, Nusstein J, Reader A, Beck M. The in vivo evaluation of hand/rotary/ ultrasound instrumentation in necrotic, human mandibular molars. *J Endod* 2007; 33:782–7.
41. Weller RN, Brady JM, Bernier WE. Efficacy of ultrasonic cleaning. *J Endod*.1980;6:740-3.
42. van der Sluis LW, Versluis M, Wu MK, Wesselink PR. Passive ultrasonic irrigation of the root canal: a review of the literature. *Int Endod J*.2007;40:415-26.
43. Senia ES, Marshall FJ, Rosen S. The solvent action of sodium hypochlorite on pulp tissue of extracted teeth. *Oral Surg Oral Med Oral Pathol*1971;31:96-103.
44. Hußmann M, Hahn W. Complications during root canal irrigation: Literature review and case reports. *Int Endod J* 2000;33:186-93.
45. 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 Radiol Endod*. 2010 Mar;109(3):479-84.
46. Nielsen BA, Baumgartner JC. Comparison of the endovac system to needle irrigation of root canals. *J Endod*.2007;33:611-5.
47. 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.
48. Wiggins S, Ottino JM. Foundations of chaotic mixing. *Philos Trans A Math Phys Eng Sci* 2004;362:937- 70.
49. 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.
50. Bonsor SJ, Nichol R, Reid TMS, Pearson GJ. Microbiological evaluation of photo-activated disinfection in endodontics (An in vivo study). *Br Dent J*. 2006;200(6):337-341

51. 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):634-641.
52. Nagayoshi M, Fukuizumi T, Kitamura C, Yano J, Terashita M, Nishihara T. Efficacy of ozone on survival and permeability of oral microorganisms. *Oral Microbiol Immunol.* 2004;19(4):240–6.
53. 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.
54. Matsumoto H, Yoshimine Y, Akamine A. Visualization of irrigant flow and cavitation induced by Er:YAG laser within a root canal model. *J Endod* 2011;37(6):839-843.
55. Peters OA, Bardsley S, Fong J, Pandher G, DiVito E. Disinfection of root canals with photon-initiated photoacoustic streaming. *J Endod* 2011;37(7):1008-1012.
56. Jaramillo DE, Aprecio RM, Angelov N, DiVito E, McClammy TV. Efficacy of photon induced photoacoustic streaming (PIPS) on root canals infected with *Enterococcus faecalis*: A pilot study. *Endod Prac* 2012;5(3):28-33.
57. Stabholz A, Zeltser R, Sela M, Peretz B, Moshonov J, Ziskind D, et al.. The use of lasers in dentistry: principles of operation and clinical applications. *Compend Contin Educ Dent* 2003;24:935–948.
58. Noiri Y, Katsumoto T, Azakami H, Ebisu S. Effects of Er:YAG laser irradiation on biofilm-forming bacteria associated with endodontic pathogens in vitro. *J Endod* 2008;34:826-829.
59. Leonardo MR, Guillén-Carías MG, Pécora JD, Ito IY, Silva LA. Er:YAG laser: antimicrobial effects in the root canals of dogs' teeth with pulp necrosis and chronic periapical lesions. *Photomed Laser Surg* 2005;23:295-299
- 60.61.Recent Advancements In Endodontic Irrigation Systems Dr Kingston Chellapandian¹ , Dr Vijay venkatesh kondas² , Dr Ashwin ravichandran³ , Dr sujana praveen Senior lecturer ⁴Journal of Positive School Psychology 2022, Vol.6, No.4, 3809-3822