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بسم الله الرحمن الرحيم

صدق الله العظيم

Dedication

This work is dedicated to my family, my father and mother and my friends for their great support and for always believing in me.

To my supervisor for her guidance and Support

Thank you from all my heart.

Certification of the Supervisor

I certify that this thesis entitled “**Irrigation in endodontics”** was prepared by **Saja Fatah Abdulhussein** under my supervision at the College of Dentistry/ University of Baghdad in partial fulfilment of the requirements for the for the B.D.S. Degree.

Signature

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(The supervisor)

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1.Introduction

Endodontology is the field of dentistry that studies the form, function and health of the dental pulp and the periradicular tissues that surround the root(s). Root canal treatment deals with resolving and preventing the infection of diseased pulp and periradicular tissues (**European Society of Endodontology, 2006**). The most common etiology for the pulpal and periradicular pathologies is the microorganisms or the microflora. found in the human mouth.(**Loesche WJ.1976**) These oral bacteria have the capacity to form biofilms on the hard and soft tissue in the oral cavity. The main goal in endodontic treatment is to recognize and remove those etiological factors. Debridement of the root canal by instrumentation, irrigation and removal of biofilm is considered important factor to prevent and treat endodontic disease(**Usha H et al2010**).Endodontic treatment is undertaken to retain the function of teeth with damaged pulps.The treatment comprises three major phases that may be of an equal importance for the outcome of the treatment, The three phases are: root canal preparation ,chemo-mechanical debridementand obturation(**Cohen and Burns, 1998**). Chemo-mechanical debridement includes instrumentation and irrigation. Instrumentation aims to give the canal system a shape that permits the delivery of locally used medications, as well as a root canal filling **(Nair et al., 2005**) but Instrumentation of the root canal alone is not sufficient to remove infected necrotic tissues(**Koskinen KProc Finn Dent Soc. 1981**) soAn Irrigation which is a step done Before one begins using instruments and during the whole instrumentation procedure (**John I. Ingle2010**)introduced.During the past 20 years, endodontisthas begun to appreciate the important role of irrigation in successful endodontic treatment. Over the years, research and clinical practices have concentrated on instrumentation, irrigation and medication of root canal system followed by obturation and the placement of coronal seal. It’s truly said, “Instruments shape, irrigants clean” (**Nisha Garg.Amit Garg2010**) Every root canal system has spaces that cannot be cleaned mechanically. The only way to clean these spaces (main canal, lateral, accessory canal, and isthus) is through the effective use of an irrigation solution (**Nisha Garg.Amit Garg2010**).

2. Literature review

2.1 History of irrigants

The first listed literature about the need for frequent irrigation of the root canal was advocated byTaft .He recommended the use of a ‘deodorizing agent’ like chloride of sodium(**Taft J.1859**). The early literature describes various methods for obtaining a clean canal using a variety of flushing agents and medicaments.For examplepotassium and sodium metals was introduce into canals toremovenecrotic pulp tissue (**Schreier 1893**). 20-5-% aqueous solution of sulphuric acid applied on 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 thereby producing an effervescent action and forcing debris to thesurface(**Callahan JR. 1894**). in the late 20th century studies conducted by Grossman and Meiman in 1941 led to introduction of the combined use of double strength sodium hypochlorite and hydrogen peroxide to wash out fragments of pulp tissue and dentin shavings after mechanical instrumentation. This was published later in 1943 by Grossman. At present sodium hypochlorite have been recommended for as the main irrigant for the clinical practice.

2.2 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 instrumentation but simultaneous use of some lubricating agents (RC prep, REDTAC, Glyde, etc.) make the instrumentation easier and smoother.

2.3 Root canal irrigation solutions:

The irrigation solution should provide optimum properties to fulfil the role of maximum cleaning efficacy and biofilm elimination from the root canal system along with minimum side effects. These properties are: (1) technically, provide lubrication of instrumentsused in mechanical preparation (**Grossman,1955**); (2) chemically, inactivation of bacteria through a broad antimicrobial action againstdifferent species colonized in biofilms (**Spratt et al. 2001**), and deactivation of bacterial endotoxin (**Gomes et al., 2009**); (3) physically, allow the flow of the irrigant throughout the root canal system in order to detach the biofilm structures and loosen/flush out the debris from the said system (**Kishen, 2010**); (4) the irrigant should be biocompatible, not irritant, and non-toxic to periapical human tissues (**Hülsmann et al. 2003**). There is a myriad of research regarding investigations of the use of different solutions as root canal irrigants. Despite compatibility of both water and normal saline, both solutions in conjunction with instrument debridement are not enough to render root canals free of pulp tissue, debris, and bacterial biofilm (Basrani and Haapasalo, 2012). A number of antibacterial agents were used as irrigants and their efficacy was tested. For example, Sodium hypochlorite

(NaOCl) (**Byström and Sunvqvist, 1985**), chlorhexidine gluconate (CHX) (**Ercan et al., 2004; Abdullah et al., 2005**), Ethylenediaminetetraacetic acid (EDTA) (**Bystrom and Sundqvist, 1981; Baumgartner et al., 1987**), a mixture of doxycycline, citric acid, and a detergent MTAD (**Torabinejad and Walton, 2009**)

2.4 Types of Irrigation solutions

2.4.1Normal saline

Normal salineone of the solutions thatused as irrigant in 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**)

2.4.2 Sodium hypochlorite (NaOCl)

Sodium hypochlorite is a clear, pale, green-yellow liquid with strong odor of chlorine .It is easily miscible with water and gets decomposed by light.(**Nisha Garg.Amit Garg2010**)Surveys from around the world (**Willershausen et al2014**)reported that sodium hypochlorite is the most common irrigating solution used in endodontics. Sodium hypochlorite hasmany Desirable properties:

- An effective antimicrobial and proteolytic agent(**Kuruvilla et al 1998**)
- Excellent organic tissue solvent(**Ohara P et al 1993**)
- Lubricant with fairly quick effects.

- NaOCl is consider both an oxidizing agent and a hydrolyzing agent.

Unfortunately, even though NaOCl has many desirable properties it has some limitation such as:

- Being toxic .(**Hülsmann et al2007**)
- Nonsubstantive
- Ineffective in smear layer removal (**Hülsmann et al 2007 , Kuruvilla et al 1998**)
- Corrosive.
- It may cause discoloration(**Jeansonne MJ1994**)
- Unpleasant odor.
- When NaOCl is used as a final rinse, bonding of the sealer to the dentin may be altered .(**Rocha et al 2012**)

NaOCl in concentrations between 2.5 and 6 % is the recommended percentage to be use during the whole cleaning and shaping procedure(**Gulabivala et al2010**.)

a. Mechanism of Action of Sodium Hypochlorite

At body temperature, reactive chlorine in aqueous solution exists in two forms-hypochlorite (OCl–) and hypochlorous acid (HOCl). State of available chlorine depends on pH of solution, i.e. above pH of 7.6, it is mainly hypochlorite form and below this pH, it is hypochlorous acid . Presence of 5 percent of free chlorine in sodium hypochlorite is responsible for breakdown of proteins into amino groups .The pH of commonly used sodium hypochlorite is 12, at which the OCl form exits. Hypochlorite dissolves necrotic tissue because of its high alkaline nature (pH 12) .To increase the efficacy of NaOCl solution, 1 percent sodium bicarbonate is added as buffering agent. Buffering makes the solution unstable, thus decreases its shelf life to even less than one week.

b. Factors affecting NaOCl activity:

- **Concentration**Decreasing the concentration of sodium hypochlorite solution reduces its toxicity, antibacterial effect and ability to dissolve tissues(**Johnson et al.2009**)
- **Volume**

increase the volume of an irrgant has a greater potential to significantly reduce bacteria colonies in root canal(**Siqueira at al.2000, Sedgley et al.2005**.)

- **Time**

Since antimicrobial effectiveness of sodium hypochlorite is directly related to its contact time with the canal, greater the contact time, more effective it is. This is especially important in necrotic cases(**Nisha Garg. Amit Garg2010**).

- **Temperature**

increase the temperature of a low-concentration NaOCl will increase the activity of the solution. The tissue-dissolving capacity of a 1% NaOCl solution at 45°C was found to be equivalent to that of a 5.25% solution at 20°C. In addition, the systemic toxicity of heated low-density NaOCl solutions is less than that of unheated, higher-concentration ones (**Sirtes G et al.2005**)

2.4.3 Chlorhexidine

CHX is a powerful antiseptic used commonly for the chemical control of plaque in the oral cavity.0.1%–0.2% aqueous solutions are used as mouthwash,while 2% concentration is used for root canal irrigation in endodontic treatment. The antimicrobial activity of CHX depends on the achievement of an optimal pH (5.5–7) (**Siqueira JF.2007**).CHX is bacteriostatic at lower concentrations and bactericidal at higher concentrations (**Jones C.G2000**). CHX is active against Gram-positive and Gram-negative bacteria, bacterial spores, lipophilic viruses, yeast and fungi (**Denton GW.1991**).Butthese effects are greatly reduced in the presence of organic matter, because the activity of CHX is dependent on pH(**Siqueira JF.2007**) . Although CHX kills bacteria, it is ineffective in removing biofilm and other organic substances (**Bui TB et al.2008**). A 2% solution of CHX is appropriate to achieve the desired maximal antibacterial effect at the end of chemomechanical preparation. This solution is used commonly as an intracanal medicament with calcium hydroxide (Ca(OH)2) (**Russell AD, Day MJ1993**). One reason for the widespread use of CHX is its prolonged antibacterial effect; CHX binds to hard tissues and maintains its antimicrobial action. This effect is due to the number of CHX molecules interacting with dentin (**Zamany A et al .2003**). White et al. reported that the effect of 2% CHX persisted for 72 h to 12 weeks (**White RR, Hays GL, Janer LR.1997**). The main disadvantage of CHX is the lack of tissue solubility (**Gomes PFA. 2013**). CHX is a broad-spectrum matrix metalloproteinase (MMP) inhibitor (anticollagenolytic effect). Attachment of CHX to the dentin surface increases resin infiltration into the dentinal tubules, thereby increasing the bond strength (**Gendron R et al.1999**). The toxic potency of CHX depends on the size and structure of the region exposed to it. Although CHX does not cause long-term damage to host tissues, it can cause an inflammatory response if it is extruded from root canals or injected inadvertently

(**Babich et al.1995**). CHX has several rarely occurring side effects, such as desquamative gingivitis, dental and oral pigmentation, and disgusting (bad-metallic taste in the mouth) (**Zamany et al.2003**). The heating of a lowconcentration CHX solution increases total antimicrobial efficacy while maintaining low systemic toxicity (**Evanov et al.2004**). CHX can be used in the disinfection of gutta percha. The addition of surface-active agents to a CHX product (CHX-Plus) reduces the surface tension, significantly increasing the activity against bacteria and biofilms. However, no study has examined complications that may arise when an irrigation solution with surfactant overflows from the periapical tissues in clinical practice (**Shen et al.2009**). QMix is an irrigation solution developed for use in the final root canal cleaning. A combination of CHX with an added surfactant and EDTA is used to increase penetration to the dentinal tubules (**Agrawal Vineet et al.2014,Torabinejad et al.2003**).

2.4.4 Ethylenediaminetetraacetic Acid (EDTA)

Complete cleaning of the root canal system requires the combined use of organic and inorganic tissue-dissolving irrigation solutions. As NaOCl effectively dissolves only organic tissue, other solutions should be used to remove the smear layer and debris from the root canal system. The use of demineralizing agents, such as EDTA as auxiliary solutions during root canal treatment is recommended. In 1957, Nygaart-Ostby proposed the use of chelating agents to aid in the preparation of narrow and calcified root canals. The first recommended EDTA solution had a concentration of 15% and a pH of 7.3 (**Nygaard-Ostby B 1957**). EDTA is used most commonly as a 17% neutralized solution. The solution reacts with the calcium ions in the dentin and forms soluble calcium chelates. Decalcification is a self-limiting process that eventually stops due to the lack of a chelator that will react quickly enough (**Von Der Fehr FR, Nygaard-Ostby B 1963**). Calt and Serper showed that 1 min irrigation with 10 ml of 17% EDTA solution effectively removed the smear layer from the canal wall. They observed that dentin demineralization increased with the contact time, the EDTA concentration (from 10% to 17%), and the pH (from 7.5 to 9) (**Calt S, Serper A 2002**). The ultrasonic application of 17% EDTA for 1 min is very effective for removal of the smear layer, especially from the apical third of the root, and the continuous use of liquid EDTA during root canal treatment is recommended (**Kuah HG ET AL 2009**)

2.4.5 Citric Acid (CA)

Citric Acid is also available on the market and is used at concentrations ranging from 1% to 50%. The use of 10% CA as a final irrigation solution yielded very good results in terms of smear layer removal (**Smith et al.1986**). CA has shown slightly better performance than EDTA at similar concentrations, although both solutions are highly effective in removing the smear layer from root canal walls (**Zehnder et al.2005**). In vitro studies have provided insight into the cytotoxicity of chelators. A 10% CA solution was proven to be more biocompatible than a 17% EDTA solution (**Sceiza et al.2001**). In one study, a 25% CA solution failed to destroy Enterococcus faecalis biofilms in 1-, 5-, and 10-min applications (**Moliz et al.2009**)

2.4.6 Mixture of Tetracycline Isomer, Acid, and Detergent (MTAD)

Torabinejad et al. introduced a combination of 3% doxycycline, 4.25% CA, and detergent (Tween-80) as an alternative to EDTA with the aim of improving smear layer removal. This mixture acts as a chelator and has antimicrobial activity. As it has no organic tissue-dissolving effect, its use after NaOCl at the end of chemomechanical preparation is recommended (**Torabinejad et al.2003**).MTAD is a mixture of three substances expected to affect bacteria synergistically (**Haapasalo et al.2007**). Its bactericidal effect on E. faecalis biofilm is less than that of NaOCl solution at concentrations of 1%–6%. The CA in the MTAD solution enables smear layer removal and allows doxycycline to enter the dentinal tubules and exert antibacterial effects (**Torabinejad et al.2003**). In a canal filled with AH Plus and gutta percha, the use of MTAD as a final irrigation solution significantly reduces bond strength compared with the use of EDTA (**Hashem et al.2009**). When MTAD is used instead of EDTA, resistance to tetracycline can develop in bacteria isolated from root canals (**Dahlén et al.2000**). Generally, the use of antibiotics instead of biocides, such as NaOCl and CHX, is not recommended because antibiotics have been developed for systemic use, rather than for local wound healing, and they have a narrower spectrum than do biocides (. **McDonnell et al.1999**)

2.4.7 Tetraclean

Like MTAD, is a mixture of CA, doxycycline (at a lower concentration than MTAD), and detergent. The concentration of antibiotic (doxycycline-50 mg / ml) and the type of detergent (propylene glycol) differ from those in MTAD. Tetraclean does not dissolve organic tissue, and its use after NaOCl at the end of chemomechanical preparation is recommended(**Giardino etal.2006**).Tetraclean exhibits high activity against anaerobic and facultative anaerobic bacteria. Compared with MTAD, Tetraclean is more effective against planktonic cultures of E. faecalis and in vitro biofilms composed of mixed species (**Pappen et al.2010**).

2.4.8 Hydroxyethylidene Bisphosphonate (HEBP)

Known as etidronic acid or etidronate, is a decalcifying agent that has little interaction with NaOCl. It has been proposed as an alternative to EDTA or CA (**Zehnder et al.2005**). HEBP prevents bone resorption, and thus is used as a systemic drug in the treatment of osteoporosis and Paget's disease (. **Russell et al.1999**). However, additional studies are needed to determine whether this solution improves or shortens the duration of endodontic irrigation. Demineralization with 9% or 18% HEBP is slower than that with 17% EDTA (**De-Deus et al.2008**).

2.4.9 Electrochemically Activated Water (Superoxidized Water)

Electrochemically activated solutions (ECA) are produced from tap water and salt solutions with low concentrations (**Solovyevaet al.2000**).Anolyte solutions include combinations of oxidizing agents with microbicidal activity against bacteria, viruses, fungi, and protozoa (**Prilutskii et al.1996**). They are referred to as superoxidized water or oxidative potential water (**Selkon et al.1999**). They do not damage vital biological tissues and are not toxic (**Shraev et al.1989**). Electrochemical activation has produced promising results in terms of effective root canal irrigation (**Solovyevaet al.2000**).

2.4.10 Ozonated Water

Even at a low concentration (0.01 ppm), ozone (O3) can effectively kill bacteria, including spores (**Broadwater et al.1973**). It can be produced easily with an ozone generator. Ozone dissolves easily and rapidly in water (73). In one study, the researchers compared the microbicidal activities of ozonated water and 2.5% NaOCl under sonic activation. They reported that ozonated water did not neutralize Escherichia coli or lipopolysaccharides in root canals and that the amount of remaining lipopolysaccharides may have biological effects, such as the induction of apical periodontitis (**Nogales et al.2008 ,Huth et al.2009**). Before its routine clinical use for root canal treatment, ozonated water needs to be investigated further

2.5 Factors modifying the activity of intracanal irrigants(Nisha Garg. Amit Garg2010)

- Concentration: studies show that Tissue dissolving capability of NaOCl is higher at 5.2 percent. than at 2.5 percent and 0.5 percent so the higher the concentration the more the effectiveness
- Contact: To effective, irrigant must come in contact with the substrate.
- Presence of organic tissue: Organic tissues must be removed for effective irrigation.
- Quantity of the irrigant used: Increase in quantity increases the effectiveness.

- Gauze of irrigating needle: 27 or 28 gauze is preferred for better penetration in the canal.
- Surface tension of irrigant: Lower the surface tension, better is wettability
- Temperature of irrigant: Warming the NaOCl increases its efficacy.
- Frequency of irrigation: More is frequency, better are the results.
- Level of observation.
- Canal diameter: Wider the canal, better is action of irrigant
- Age of irrigant: Freshly prepared solutions are more efficient then older ones

2.6 Methods of irrigation

The effectiveness and safety of irrigation depends on the means of delivery. Traditionally, irrigation has been performed with a plastic syringe and an open-ended needle through which the irrigant solution enters the canal space.(**haapasalo et al .2010**).Putting in mind the following point while irrigating the canal: 1. The solution must be introduced slowly and passively into the canal. 2. Needle should never be wedged into the canal and should allow an adequate back-flow 3. Blunted needle of 25 gauge or 27 gauge are preferred. 4. In case of small canals, deposit the solution in pulp chamber Then file will carry the solution into the canal. 5. Canal size and shape are crucial for irrigation of the canal. For effective cleaning of apical area, the canals must be enlarged to size 30 and to larger size.

6. Regardless of delivery system, irrigants must never be forcibly inserted into apical tissue rather gently placed into the canal. 7.

For effective cleaning, the needle delivering the solution should be in close proximity to the material to be removed. 8. In case of large canals, the tip of needle should be introduced until resistance is felt, then withdraw the needle 2-3 mm away from that point and irrigate the canal passively. 9. In order to clean effectively in both anterior and posterior teeth canals, a blunt bend of 30° in the center of needle can be given to reach the optimum length to the canal . 10. Volume of irrigation solution is more important than concentration or type of irrigant. (**Nisha Garg.Amit Garg2010**).

2.6.1 needle-tip size and designs

Although 25-gauge needles were common for endodontic irrigation a few years ago, they were replaced by 27-G needles, 30-G and even 31-G needles are taking over for routine use inirrigation.As27 G corresponds to International StandardsOrganization size 0.42 and 30 G to size 0.31, smaller needle sizes are preferred. 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. However, although the smaller needles allow delivery of the irrigant close to the apex, this is not without safety concerns. Several modifications of the needle design have been introduced to fulfit the ideal properties of needles (should be blunt. 2.allow back-flow. 3.flexible. 4.Longer in length. 5. Easily available. 6. Cost-effective.)

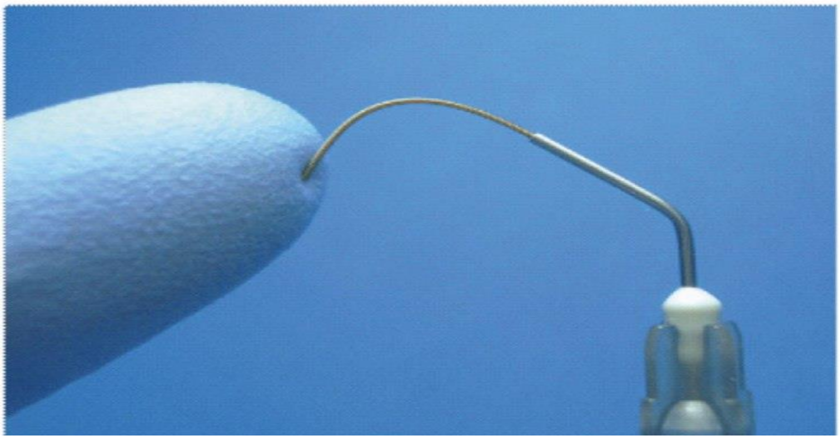

Figure1: Haapasalo et al.2010

2.6.2 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 design. Because of the chemical reactions between many irrigants, separate syringes should be used for each solution (**Markus Haapasalo, et al.2010**)

Figure 2: Haapasalo et al.2010

2.6.3 Brushes

Strictly speaking, 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. They might also be indirectly involved with the transfer of irrigants within the canal spaces. Recently, 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 microscope (**Migun et al.1996**) . During the early 1990s, similar findings indicating improved canal debridement with the use of canal brushes were reported by Keir et al .They used the Endobrush in an active brushing and rotary motion. The Endobrush (C&S Microinstruments Ltd, Markham, Ontario, Canada) is a spiral brush designed for endodontic use that consists of nylon bristles set in twisted wires with an attached handle and has a relatively constant diameter along the entire length. However, 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 (**Al-Hadlaq et al.2006)**

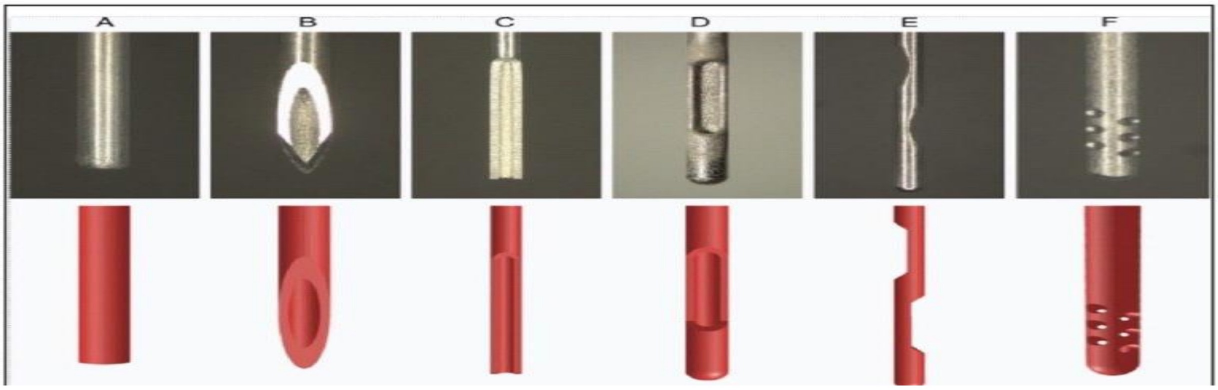

figure 3: Haapasalo et al.2010

2.7 Agitation

For many years various methods have been proposed and developed to make root canal irrigants more effective in removing debris and bacteria from the root canal system. The physical and chemical objectives of irrigation can be enhanced through agitation of the irrigant by distributing the irrigant and creating shearing and streaming forces throughout the root canal system

These techniques can be classified into two broad categories: manual and rotary agitation.(**Gu et al.2009**).The manual irrigation techniques include irrigation with needles, agitation with brushes, and manual dynamic agitation with files or gutta-percha points. The rotary irrigation techniques include rotary brushes, continuous irrigation during instrumentation, sonic and ultrasonic vibrations, and application of negative pressure during irrigation of the root canal system. The use of these methods results in better canal cleanliness when compared with that of conventional syringe needle irrigation.

A) ManualagitatIon techniques

Although the Conventional irrigation with syringes has been advocated as an efficient method of irrigant delivery before the advent of passive ultrasonic activation.. The technique involves

dispensing of an irrigant into a canal through needles/cannulas of variable gauges, either passively or with agitation which 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(**Gu et al.2007**). 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 procedures. Several studies have shown that the irrigant has only a limited effect beyond the tip of the needle because of the deadwater zone or sometimes air bubbles in the apical root canal, which prevent apical penetration of the solution (**Boutsioukis et al.2010**)
needle penetration withinthe and the volume of irrigant that is flushed through the canal (**Sedgley et al.2005**)

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 (**Ruddle CJ.2001**)

Factors Affecting Manual dynamic Irrigation Several factors could have contributed to the positive results of 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;

(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; and

(3) The push-pull motion of the gutta-percha point probably acts by physically displacing, folding, and cutting of fluid under ‘‘viscouslydominated flow’’ in the root canal system. The latter probably allows better mixing of the fresh unreacted solution with the spent, reacted irrigant. Although manual-dynamic irrigation has been advocated as a method of canal irrigation as a result of its simplicity and costeffectiveness, the laborious nature of this hand-activated procedure still hinders its application in routine clinical practice. Therefore, there are a number of automated devices designed for agitation of root canal irrigants that are either commercially available or under production by manufacturers(**Ruddle CJ.2001**)

B). Mechanical agitation technique

1. Rotary Brush Both Ruddle brush and Canal Brush both fit in this category. I. A rotary handpiece–attached microbrush has been used to facilitate debris and smear layer removal from instrumented root canals(**Weise et al.2007**). The brush includes a shaft and a tapered brush section. The latter has multiple bristles extending radially from a central wire core. 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. However, this product has not been commercially available since the patent was approved in 2001. 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 (**Tronstad et al.1985**)

2. continuous Irrigation during Rotary Irrigation TheQuantec-E irrigation system (Sybron Endo, Orange, CA) is a self-contained fluid delivery unit that is attached to the Quantec-E Endo System. It uses a pump console, two irrigation reservoirs, and tubing to provide continuous irrigation during rotary instrumentation (**Walters et al., 2002**).

3. Sonic Irrigation Sonic instruments for endodontics were first reported by Tronstadet al.,(**Tronstad et al.1985**). Sonic irrigation operates at a lower frequency (1–6 kHz) and produces smaller shear stresses than ultrasonic irrigation et al.,(**Ahmad et al.1987**). The Endo Activator is one form of the sonic irrigation that uses noncutting polymer tips to quickly and vigorously agitate irrigant solutions during treatment. A study has shown this method to be effective [Table/Fig-6].

Vibringe

Vibringe is a new sonic irrigation system that combines battery-driven vibrations (9000 cpm) with manually operated irrigation of the root canal. Vibringe uses the traditional type of syringe/needle delivery but adds sonic vibration. (**Migun et al.1996**).

4. ultrasonic Irrigation Ultrasonics is another group of instruments that can be used for irrigation in the ultrasonics and subsonic handpieces. Ultrasonic handpieces pass sound waves to an endodontic file and cause it to vibrate at ~25,000 vibration/s. It cuts dentin as well as causes acoustic streaming of the irrigant (Martin and Cunningham). It was also found that debris dislodgment from canal walls occurs through cavitation occurring within the irrigating solution. The dental literature has described two types of ultrasonic irrigation. The first one is a combination of simultaneous ultrasonic instrumentation and irrigation (UI). The second one operates without simultaneous instrumentation and is referred to as passive ultrasonic irrigation (PUI). PUI is more effective than syringe needle irrigation at removing pulpal tissue remnants and dentine debris. This may be due to the much higher velocity and volume of irrigant flow that are created in the canal during ultrasonic irrigation. Ultrasonics can effectively clean debris and bacteria from the root canal system, but cannot effectively get through the apical vapor lock (**Ruddle CJ.2008**)

Positivepressure versus apical negative pressure There are two 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. Yet, it is difficult for these irrigants to reach the apical portions of the canals because of air entrapment, when the needle tips are placed too far away from the apical end of the canals. Conversely, if the needle tips are positioned too close to the apical foramen, there is an increased possibility of irrigant extrusion from the foramen that might result in severe iatrogenic damage to the periapical tissues(**Gu et al.2009**).Concomitant irrigant delivery and aspiration via the use of pressure alternation devices provide a plausible solution to this problem

5. Pressure Alternation devices

The RinsEndo irrigation system and the EndoVac irrigation system are examples of negative-pressure irrigation.

- The RinsEndo irrigation system irrigates the canal by using pressuresuction technology. It is composed of a handpiece, a cannula with a 7-mm-long exit aperture, and a syringe carrying irrigant(**McGill S et al.2008**).
- The EndoVac system is regarded as an apical negative pressure irrigation system composed of three basic components: a Master Delivery Tip (MDT), the Macrocannula, and the Microcannula. The MDT delivers irrigant to the pulp chamber and evacuates the irrigant concomitantly. Both the macrocannula and microcannula are connected via tubing to a syringe of irrigant and the highspeed suction of a dental unit. The Macrocannula is made of plastic flexiblepolypropylene with

an open end of 0.55 mm in diameter, an internal diameter of 0.35 mm, and a 0.02 taper, used to suction irrigants up to the middle segment of the canal. Lastly, the Microcannula is made of stainless steel and has 12 microscopic holes disposed in four rows of three holes, laterally positioned at the apical 1 mm of the cannula. Each hole is 0.1 mm in diameter, the first one in the row is located 0.37 mm from the tip of the microcannula, and the distance between holes is 0.2 mm. The microcannula has a closed end with external diameter of 0.32 mm can be used in canals that are enlarged to size 35 or larger, and should be taken to the working length (WL) to aspirate irrigants and debris. During irrigation, the MDT 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 the irrigant from its fresh supply in the chamber by the MDT, 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. Nielsen and Baumgartner

(**Nielsen BA et al.2007**) compared the efficacy of the EndoVac system and needle irrigation to debride the apical 3 mm of a root canal. No significant difference between the two irrigation techniques was noted at the apical 3 mm level. But at 1 mm apical level, the EndoVac system significantly resulted in less remaining debris. The Endovac irrigation system was also shown to achieve better microbial control than the traditional irrigation delivery system (**Hockett et al.,Miller and Baumgartner.2008**). Another in vitro study indicated that EndoVac left significantly less debris behind than the conventional 30-gauge needle irrigation methods (**Shin et al.2010**).

Figure 4: Haapasalo et al.2010

CONCLUSION

Endodontic success is greatly dependent on the elimination of microorganisms during cleaning and shaping. Care should be administered to the fact that the irrigant must be employed such that it can act to its full potential in the root canals. The choice of irrigants varies from practitioner to practitioner. No irrigant till date provides 100% elimination of bacteria and cleansing the root canal. However, despite the complications, NaOCl is the gold standard irrigant used in day to day clinical practice. Proper administration of the desired irrigant helps to achieve sufficient antimicrobial effect and thereby boosting the endodontic success.

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