

Endodontic Irrigation System: Manual vs Machine Assisted

Pheiroijam Herojit Singh^{1*}, Ningthoukhongjam Rati Devi² and N Sukumar Singh³

¹Post-Graduate Student, Department of Pediatric and Preventive Dentistry, Jaipur Dental College, Rajasthan, India

²Assistant Professor, Department of Conservative Dentistry and Endodontics, Dental College JNIMS, Imphal, Manipur, India

³Associate Professor, Department of Conservative Dentistry and Endodontics, Dental College JNIMS, Imphal, Manipur, India

***Corresponding Author:** Pheiroijam Herojit Singh, Post-Graduate Student, Department of Pediatric and Preventive Dentistry, Jaipur Dental College, Rajasthan, India.

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Abstract

A successful endodontic therapy depends on proper instrumentation, irrigation and obturation of root canals. Debridement of root canals with the goal to remove micro-organisms, pulp remnants and dentin debris is one key factor for success of root canal treatment. There is no single irrigation system which fulfills all functions from an irrigant. The root canals are subjected to constant irrigation and shaping to remove inflamed and necrosed tissues, micro-organisms, debris and biofilms. The success of irrigation can be achieved when correct protocols are followed. Threat to the success of irrigation is often posed by the presence of fins, isthmuses and lateral accessory canals. Several irrigation techniques and systems have been adopted. In this review literature manual and machine assisted irrigation systems will be discussed in details.

Keywords: Biofilm; Debridement; Root Canal; XP-3D; XP Endo

Introduction

The success of endodontic treatment depends on complete removal of micro-organisms and protection from re-infection of root canals. Proper instrumentation enhanced with constant irrigation results in lubrication between instrument and canal wall, increases efficiency of cutting and removal of debris with micro-organisms and their toxins. For successful endodontic therapy pulp tissue remnants, micro-organisms and their toxins are required to be completely removed from the root canals [1]. Even though this could be achieved by means of chemo-mechanical debridement [2], but it is sometime impossible to shape and clean the root canal completely [3] because of the intricate nature of root canal anatomy. Even with rotary instrumentation during root canal preparation the lateral accessory canals are left without being prepared. These areas may provide shelter for micro-organisms and other debris which might prevent close 3-dimensional adaptation of the obturation material resulting in recurrent inflammation. Hence irrigation makes root canal free from micro-organisms and their toxins which is difficult to achieve by instrumentation alone. Ideal root canal irrigant should solve all problems described above for endodontic success. Thus, in clinical endodontic practices, combination of irrigants like sodium hypochlorite (NaOCl) and EDTA or chlorhexidine (CHX) are used to solved the undesirable results of using a single irrigant. These irrigants must come in contact with the canal walls at the apical region of most importantly that of small root canals. Effective irrigant delivery systems have been developed. These systems might be divided into 2 broad categories, manual agitation techniques and machine-assisted agitation devices. The objective of this review is to provide the detail information on the principles and applications of different manual as well as machine assisted irrigation systems available so far in clinical endodontics.

Manual agitation techniques

Syringe irrigation with needles/cannulas

Conventional irrigation with syringes has been advocated in all clinical practices as an efficient method of irrigation. The technique involves introduction of an irrigant into the root canals using needles of varying sizes passively or with agitation. The agitation method is achieved by moving the needle up and down inside the canal. The needles may be open-ended or closed-ended with side vents on the lat-

eral aspect. The close-ended with side vent design improves the hydrodynamic action of irrigants and reduces apical overflow of irrigants. It is crucial that there must be space between needle/cannula and the canal walls during irrigation. This method permits debridement of root canals in the coronal region only. One advantage of this method is easy to control the depth of the needle during placement [4].

Brushes

Brushes are used as an aid for debridement of root canals through agitation. They help in introducing the irrigant into the root canals indirectly. A recent study has reported that the NaviTip FX needle was more advantageous than the brushless type of NaviTip needle. During the early 1990s, Keir, *et al.* used the Endobrush in an active brushing and rotary motion to improve the debridement of root canal walls. The Endobrush (CandS Microinstruments Ltd, Markham, Ontario, Canada) is a spiral brush that consists of nylon bristles set in twisted wires with an attached handle. It has a relatively constant diameter along the entire length. Canal preparation with Endobrush was found to be more effective in debridement than instrumentation alone [5]. However, the Endobrush are not used for debridement upto the working length because the debris is likely to pack at the apical region.

Manual-dynamic irrigation

For effective action an irrigant must be in direct contact with the canal walls. Because of vapor lock effect irrigants are unable to reach the apical region for effective debridement. A gently moving well-fitting gutta-percha master cone up and down in short strokes of 2 - 3 mm (manual dynamic irrigation) within an instrumented canal can produce an effective hydrodynamic effect. It was confirmed by McGill, *et al.* and Huang, *et al.* The studies had illustrated that manual-dynamic irrigation was found more effective than an automated-dynamic irrigation system (RinsEndo; Dürr Dental Co, Bietigheim-Bissingen, Germany) and static irrigation. Factors that may have contributed for the positive results of manual dynamic agitation are: (1) Increase in intracanal pressure due to up and down stroke of the master gutta percha point; (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 “viscously-dominated flow” in the root canal system.

Machine-assisted agitation systems

Rotary brushes

A rotary handpiece-attached micro brush has been used by Ruddle [6] to facilitate debris and smear layer removal from instrumented root canals. The brush includes a shaft and a tapered brush section consisting of multiple bristles extending radially from a central wire core. CanalBrush (Coltene Whaledent, Langenau, Germany), an endodontic microbrush with highly flexible microbrush has been made available in the market and might be used manually with a rotary action. CanalBrush is more effective when connected to a contra-angle handpiece at 600 rpm.

Continuous irrigation during rotary instrumentation

The Quantec-E irrigation system (SybronEndo, Orange, CA), a delivery unit attached to the Quantec-E Endo System uses a pump console, 2 irrigation reservoirs, and tubing to provide continuous irrigation during rotary instrumentation [7]. As compared with needle irrigation, Quantec-E irrigation is more effective in cleaning debris at the coronal third of canal walls but not in middle and apical third of root canals. It was confirmed by Walters, *et al.* there was no significant difference between standard syringe needle irrigation and irrigation with the Quantec-E pump.

Sonic irrigation

Tronstad., *et al.* [8] were the first to report the use of a sonic instrument for endodontics in 1985. Sonic irrigation operates at a lower frequency (1–6 kHz) and produces smaller shear stresses than ultrasonic irrigation. Sonic irrigation is usually performed by using a Rispi-sonic file attached to a MM 1500 sonic handpiece (Medidenta International, Inc, Woodside, NY) after instrumentation. The Rispi-sonic files have a non-continuous taper that increases with file size and are barbed.

Recently a sonically driven canal irrigation system called EndoActivator System (Dentsply Tulsa Dental Specialties, Tulsa, OK) is introduced [9]. The system consists of a portable handpiece and 3 types of disposable tips of different sizes. These tips are smooth and do not cut the dentin and hence able to effectively clean debris from lateral canals, remove the smear layer, and dislodges clumps of simulated biofilm within the curved canals of molars.

Ultrasonic system

Richman [10] introduced ultrasound to endodontics as a means of canal debridement in 1957. In 1980, an ultrasonic unit designed by Martin., *et al.* became commercially available for endodontic use. There are two types of ultrasonic irrigation: 1) combination of simultaneous ultrasonic instrumentation and irrigation (UI) and 2) passive ultrasonic irrigation (PUI), operates without simultaneous instrumentation.

The term PUI was first used by Weller., *et al.* [11] to describe an irrigation system where there was no instrumentation. During PUI, an oscillating file is used to introduce the irrigant into the canal by means of ultrasonic waves which produces acoustic streaming and cavitation of the irrigant.

Two flushing methods might be used during PUI, namely a continuous flush of irrigant from the ultrasonic handpiece or an intermittent flush technique by using syringe delivery.

Continuous ultrasonic irrigation

Nusstein [12] had developed an ultrasonic handpiece with needle holding adapter. A 25 gauge needle is used to deliver the irrigant instead of endodontic file. The irrigant can also be delivered apically through the needle.

Intermittent flush ultrasonic irrigation

In this system, the irrigant is delivered to the root canal by a syringe needle. The irrigant is then activated by using an ultrasonically oscillating instrument.

Pressure alternation devices

There are two disadvantages associated with conventional syringe needle delivery of irrigants. First, it is difficult for the irrigants to reach the apical portion when the needle tips are placed far from the apical region. Secondly, if the needle tips are too close to the apical foramen, there is a high chance of apical flow of irrigant causing inflammation to periapical tissue. Here pressure alternative system provides the ultimate solution.

Lussi., *et al.* [13] developed the non-instrumentation technology (NIT) as the first experimental pressure alternation system. This technique did not enlarge the canal but created bubble implosion and hydrodynamic turbulence that facilitated penetration of the NaOCl into the canal ramifications. Another experimental pressure alternation irrigation system was introduced by Fukumoto., *et al.* [14] that

comprised an injection needle (external diameter, 0.41 mm; internal diameter, 0.19 mm; Nipro Co, Osaka, Japan) and an aspiration needle (external diameter, 0.55 mm; internal diameter, 0.30 mm; Terumo Co, Tokyo, Japan) connected to an apex locator (Root ZX; J Morita USA, Inc, Irvine, CA). When NaOCl was introduced coronally by a needle and the used irrigant is aspirated with an aspiration needle at 2 mm from the apex.

The EndoVac System

In the EndoVac system (Discus Dental, Culver City, CA), a macro cannula or micro cannula having a size of 55 open end with a 0.02 taper connected via tubing to a syringe of irrigant and the high-speed suction of a dental unit [15]. During irrigation, the delivery tip delivers irrigant to the pulp chamber and siphons off the excess irrigant to prevent overflow. The cannula inside the canal simultaneously exerts negative pressure that draws 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.

The RinsEndo system

The RinsEndo system (Dürr Dental Co), based on pressure suction principle consist of 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 via an adapted cannula. In the suction process, the used irrigant mixed with air are sucked from the root canal and automatically merged with fresh rinsing solution. The pressure-suction cycles change approximately 100 times every minute.

Newer irrigation systems in endodontics

Gentlewave irrigation

Gentlewave (GW) (Sonendo, Laguna Hills, CA, USA) system aims to clean the root canal through generation of different physiochemical mechanisms including a broad spectrum of sound waves. Multisonic waves are initiated at the tip of GentleWave™ handpiece, which is positioned inside the pulp chamber [16]. It delivers a stream of treatment solution from the handpiece tip into the pulp chamber while excess fluid is simultaneously removed by the built-in vented suction through the handpiece. Upon initiation of flow through the treatment tip of the handpiece, the stream of the treatment fluid interacts with the stationary fluid inside the chamber creating a force which causes hydrodynamic cavitation. The continuous formation of micro bubbles inside cavitation cloud generates acoustic field with broadband frequency spectrum that travels through the fluid into the entire canal [17].

According to Haapasalo, *et al.* [17] the GW System provides tissue dissolution of eight and ten times faster than ultrasonic devices and needle irrigation, respectively. A study showed that GW system Gentle removed CH within 90 sec using water irrigation alone. According to Molina, *et al.* the GW system showed greater cleaning and reduction in residual debris within the canals than those cleaned conventionally. The efficacy of GW system in removing separated instruments from the root canal has also been reported. In a multi-center clinical study, Sigurdsson, *et al.* reported 97% successful healing in the teeth treated with the GW System at 12 months.

Antimicrobial photodynamic therapy (APDT)

APDT is a two-step procedure that involves the application of a photosensitizer, followed by light illumination of the sensitized tissues, which would generate a toxic photochemistry on target cells, leading to killing of microorganisms. Nowadays, APDT is considered as a supplement to traditional protocols for canal disinfection. In an approach to adapt and improve the antimicrobial efficacy of APDT in endodontics, recent research has developed novel formulations of photosensitizers that displayed effective penetration into dentinal tubules, anatomical complexities, and anti-biofilm properties. APDT may be combined with the usual mechanical instrumentation and chemical antimicrobials. Garcez, *et al.* compared the effectiveness of APDT, standard root canal therapy and the combined treatment to eliminate

bacteria present in infected canals. Findings showed that root canal therapy alone reduced bacteria by 90% while APDT alone reduced it by 95%. The combination of two procedures reduced it by > 98%. The bacterial regrowth observed 24 h after treatment was much more for either single treatment than the combination.

Photon-induced photo-acoustic streaming (PIPS)

PIPS is based on the radial firing stripped tip with laser impulses of sub-ablative energies of 20 mJ at 15 Hz for an average power of 0.3W at 50 μ s impulses. These impulses induce interaction of water molecules with peak powers of 400W. This creates successive shock waves leading to formation of a powerful streaming of the antibacterial fluid located inside the canal, with no temperature rising. Unlike the conventional laser applications, the unique tapered PIPS tip is not mandatory to be placed inside the canal itself but rather in the pulp chamber only. This can reduce the need for using larger instruments to create larger canals so that irrigation solutions used during treatment can effectively reach to the apical part of the canal and also canal ramifications. This procedure can effectively remove both vital and non-vital tissues, kill bacteria, and disinfect dentin tubules.

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.

Gram negative bacteria are more sensitive to ozonated water than gram positive oral streptococci and *C. albicans* in pure culture. Notably, when the specimen was irrigated with sonication, ozonated water had nearly the same antimicrobial activity as 2.5% NaOCl. 28 Ozone works best when there is less organic debris remaining. Therefore, the recommendation is to use either ozonated water or ozone gas at the end of the cleaning and shaping process. Ozone is effective when it is used in sufficient concentration, for an adequate time. Ozone will not be effective if too little dose of ozone is delivered or it is not delivered appropriately.

The VATEA system

The VATEA system is an irrigation device which is an integral part of Self Adjusting file rotary system (SAF). The VATEA system is a self-contained, fluid delivery unit intended to be attached to dental handpiece to deliver irrigation during endodontic procedures. During the endodontic treatment, irrigation solution is pumped from the VATEA's 400 ml reservoir. The irrigant is delivered via a disposable silicone tube to the endodontic file. The flow of irrigant is toggled using a foot pedal. The operator can adjust the flow rate from 1 - 10 ml/min by using the -/+ push buttons located on the control panel. A recent independent study by Prof. Jose Siqueira from Estácio de Sá University, Brazil, indicated that in oval canals the SAF SYSTEM was found superior to rotary Ni-Ti files used with needle irrigation (NaOCl).

The Vibringe system

The Vibringe System is 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 Luer-Lock 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. The irrigant is sonically activated, as is the needle that attaches to the syringe. Rödiger, *et al.* evaluated the efficacy of vibringe system they concluded that vibringe 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.

Maxi-i-probe

Maxi-i-probe is a modified design of regular manual irrigation needles with a well-rounded, close tip and side-port dispersal. This needle is available in a wide range of gauges from 21 to 30 gauge. The luer lock connector provides a secure attachment and easy removal from any disposable syringe. The manufacturer claimed that the rounded tip prevents the risk of perforating the apex and allows for safe irrigation of the entire length of the root canal. The dispersal of the irrigating solution through the side-port in the cannula creates a unique upward turbulent motion, which thoroughly irrigates the root canal preparation but prevents solution and debris from being expressed through the periapical foramen.

The manual needle irrigation systems allow good control of needle depth and the volume of irrigant that is flushed through the canal. The disadvantages of conventional needle irrigation are: 1) the irrigating solution was delivered only 1 mm deeper than the tip of the needle; 2) difficult to access the apical third of the canal; 3) irrigation is relatively weak; and 4) inaccessible canal extensions and irregularities are likely to harbor debris and bacteria, thereby making thorough canal debridement difficult.

Endo Irrigator Plus

Endo Irrigator Plus (K Dent Dental System) is an irrigating system based on ACWIS (Activated continuous warm irrigation and evacuation system) concept. In this unit NaOCl is warmed upto 45°. This device creates positive and negative pressure inside the canal. Positive pressure irrigation with warm NaOCl cleans and disinfects up to the middle third and removes all macro debris. All micro and nano debris from the apical third are removed by Negative pressure irrigation with warm NaOCl and area is cleaned and disinfected. Trials done under electronic microscope found that this device actually helps penetration of NaOCl into the lateral and accessories canals. Strong vacuum evacuation system prevents over extrusion of NaOCl. This irrigation system has also proved effective against AVL.

XP Endo Finisher

In 2015, FKG manufactured an equally singular file, the XP Endo Finisher® (XPEF), which was developed with the purpose of refining the canal in order to increase the effect of irrigants and improve smear layer removal from the walls. The instrument is made up of an alloy patented by FKG called MaxWire (Martensite-Austenite Electropolish -FleX, FKG Dentaire). According to the manufacturer, the file is straight in M phase when cooled, and it changes into A phase when exposed to body temperature where it will have its unique spoon shape with a length of 10 mm from the tip and a depth of 1.5 mm because of its molecular memory. It is suggested to be used at 800 rpm and 1.0 Newton Torque with irrigating solution after root canal preparation to size #25 or longer. The instrument's diameter is ISO #0.25 and its taper is equal to 0.

The XP-3D Finisher

The XP-3D Finisher utilizes Brasseler's exclusive MaxWire Technology to adapt to the canal's natural anatomy. It has a bowed shape at body temperature and is incredibly flexible. The instrument debrides the root canal system 3-dimensionally and allows for enhanced irrigation. The XP-3D Finisher is intended to clean a prepared canal and will not change the shape once prepared. It is an ISO #25 with a 0° taper. Its capacity to expand improves its reach 100-fold compared to a standard instrument. It should be used only canal preparation to at least #25.

Conclusion

None of the irrigation system serves all the purpose of irrigation. Hence, new irrigation systems using advance technology have been development. They have better improvement in ability to debride the root canals. However, conventional systems are still used in clinical practices.

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