Review Article

Irrigation technique used in cleaning and shaping during endodontic treatment - A review

P. Ragul, M. Dhanraj, Ashish R. Jain*

ABSTRACT

The success of 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. Moreover, during the preparation of root canal, manually and by rotary instruments, the smear layer is created that must be eliminated by irrigants. Irrigants have traditionally been delivered into the root canal space using syringes and metal needles of different size and tip design. This review summarizes the various irrigants and their delivery devices used in clinical practice.

KEY WORDS: Endodontics, Irrigants, Microorganisms, Root canal, Smear layer

INTRODUCTION

The success of endodontic treatment depends on the elimination of the existing bacteria in root canal system and preventing their regrowth. Removing debris, biofilm, microbes, and necrotic tissues from the root canal system are performed manually or through rotary shaping, as well as frequently canal irrigation. The main objective of preparation and canal shaping is to facilitate canal irrigation, disinfection, and obturation. There is no irrigant that is capable of providing all the expected characteristics; ideal irrigation is feasible using a combination of two or more appropriate solutions through a certain sequence. Accordingly, the chemical composition of canal irrigants has been changed to improve penetration and the effects of irrigation. Irrigants must be brought into direct contact with the entire canal wall surfaces for effective action particularly for the apical portions of small root canals. Various methods have been developed to provide effective delivery. These systems might be divided into two broad categories, manual agitation techniques and machine-assisted agitation devices. The objective of this review was to present an overview of contemporary irrigation methods available in endodontics.

Access this article online	
Website: jprsolutions.info	**ISSN:** 0975-7619

PURPOSE OF ENDODONTIC IRRIGATION

Root canals are very anatomically complex. Many teeth will have at least one or more lateral or accessory canals, which often cannot be seen on a radiograph and are too small to instrument. Therefore, even with thorough preparation and instrumentation, organic (e.g., pulp) tissue and inorganic (e.g., remains of the previous restoration) will still exist within the root canal. In addition, bacteria reside in the dentinal tubules within the root canal. This makes these areas impossible to clean with mechanical instrumentation alone. It is imperative that the whole root canal system is disinfecting to prevent bacterial growth, after the root canal treatment has been carried out, and reoccurrence of infection. Instrumentation does not completely clean the root canal and leaves behind vital, infected and necrotic pulp tissue. This must be removed as it can be a source of nutrients for bacteria within the root canal system. Many irrigants have the ability to dissolve pulp tissue.

MANUAL AGITATION TECHNIQUES

Syringe Irrigation with Needles/Cannulas

Conventional irrigation with syringes has been advocated as an efficient method of irrigant delivery

Department of Prosthodontics, Saveetha Dental College and Hospitals, Saveetha University, Chennai, Tamil Nadu, India

***Corresponding author:** Dr. Ashish R. Jain, Department of Prosthodontics, Saveetha Dental College and Hospital, Saveetha University, Poonamallee High Road, Chennai - 600 127, Tamil Nadu, India. Phone: +91-9884233423. E-mail: dr.ashishjain_r@yahoo.com

Received on: 23-02-2018; Revised on: 21-04-2018; Accepted on: 20-05-2018

before the advent of passive ultrasonic activation. This technique is still widely accepted by both general practitioners and endodontists. The technique involves dispensing of an irrigant into a canal through needles/cannulas of variable gauges, either passively or with agitation. The latter is achieved by moving the needle up and down the canal space. 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.[1] 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 dead-water zone or sometimes air bubbles in the apical root canal, which prevent apical penetration of the solution.[2,3]

Needle-tip Design

The smaller needles allow delivery of the irrigant close to the apex, this is not without safety concerns. Several modifications of the needle-tip design have been introduced in recent years to facilitate effectiveness and minimize safety risks. 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. This allows the irrigant to reflux and causes more debris to be displaced coronally, while avoiding the inadvertent expression of the irrigant into periapical tissues.[4] One of the advantages of syringe irrigation is that it allows comparatively easy control of the depth of needle penetration within the canal and the volume of irrigant that is flushed through the canal.[5,6]

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. NaviTip Fx is a 30-gauge irrigation needle covered with a brush was introduced commercially by Ultradent company. Brush is an adjunct that has been designed for debridement of the canal walls or agitation of root canal irrigant. NaviTip FX needle gave improved cleanliness in coronal third when compared to brushless NaviTip needle. Nevertheless, the differences in the apical and middle thirds were not statistically significant.[6] NaviTip FX brush bristles may dislodge inside the canal irregularities due to the friction, because of its radiolucent nature it is very difficult to identify radiographically and even with the use of a surgical microscope.[1]

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.[7,8] Research has shown that gently moving a well-fitting gutta-percha master cone up and down in short 2–3-mm strokes within an instrumented canal can produce an effective hydrodynamic effect and significantly improve the displacement and exchange of any given reagent.[9,10] This was recently confirmed by the studies of McGill *et al*.[11] and Huang *et al.*[12] Several factors could have contributed to the positive results of manual-dynamic irrigation:

- 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;
- 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;
- The push-pull motion of the gutta-percha point probably acts by physically displacing, folding, and cutting of fluid under “viscously-dominated flow”[13] 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 cost-effectiveness, 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.

MACHINE-ASSISTED AGITATION SYSTEMS

Rotary Brushes

A rotary handpiece-attached microbrush has been used by Ruddle[14] to facilitate debris and smear layer removal from instrumented root canals. 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. CanalBrush (Coltene Whaledent, Langenau, Germany) is an 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. However, it is more efficacious when attached to a contra-angle handpiece running at 600 rpm. A recent report by Weise *et al*.[15] showed that the use of the small and flexible CanalBrush with an irrigant removed debris effectively from simulated canal extensions and irregularities.

The Quantec-E irrigation System

The Quantec-E irrigation system was introduced by SybronEndo company is a self-contained fluid delivery unit that is attached to the Quantec-E Endo System. It uses a pump console, 2 irrigation reservoirs, and tubing to provide continuous irrigation during rotary instrumentation. It has been proposed that continuous irrigant agitation during active rotary instrumentation would generate an increased volume of irrigant, increase irrigant contact time, and facilitate greater depth of irrigant penetration inside the root canal. This should result in more effective canal debridement compared with syringe needle irrigation. However, studies conducted by Setlock *et al*.[16] and Walters *et al*.[17] proved that Quantec-E irrigation did result in cleaner canal walls and complete debris and smear layer removal in the coronal third of the canal walls and there was no significant difference between standard syringe needle irrigation and irrigation with the Quantec-E pump.

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.[18-20]

Sonic Irrigation

Tronstad *et al*.[21] were the first to report the use of a sonic instrument for endodontics in 1985. Sonic irrigation is different from ultrasonic irrigation in that it operates at a lower frequency (1–6 kHz) and produces smaller shear stresses.[22] The sonic energy also generates significantly higher amplitude or greater back and forth tip movement. Moreover, the oscillating patterns of the sonic devices are different compared with ultrasonically driven instruments. A minimum oscillation of the amplitude might be considered a node, whereas a maximum oscillation of the amplitude represents an antinode. They have 1 node near the attachment of the file and 1 antinode at the tip of the file.[23] When the movement of the sonic file is constrained, the sideway oscillation disappears. This results in a pure longitudinal file oscillation. This mode of vibration has been shown to be particularly efficient for root canal debridement because it is largely unaffected by loading and exhibits large displacement amplitudes.[23]

Pressure Alteration Device

There are apparently dilemmatic phenomena associated with conventional syringe needle delivery of irrigants. It is desirable for the irrigants to be in direct contact with canal walls for effective debris debridement and smear layer removal. Yet, it is difficult for these irrigants to reach the apical portions of the canals because of air entrapment,[24] 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.[25] Concomitant irrigant delivery and aspiration through the use of pressure alternation devices provide a plausible solution to this problem

The EndoVac system

The EndoVac apical negative pressure irrigation system has been introduced by Discus Dental Company. It has three components: The Master Delivery Tip, MacroCannula, and MicroCannula. 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 through 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 through tubing to the high-speed suction of a dental unit.[10] 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 Microcannula 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. Apical negative pressure has been shown to enable irrigants to reach the apical third and help overcome the issue of apical vapor lock.[26,27] In studies comparing the efficacy of EndoVac with other systems such as passive ultrasonic, F File, the Manual Dynamic Max-I-Probe, the Pressure Ultrasonic, and the EndoActivator revealed only the EndoVac was capable of cleaning 100% of the isthmus area.[28-30] Apart from being able to avoid air entrapment, the EndoVac system is also advantageous in its ability to safely deliver irrigants to working length without causing their undue extrusion into the periapex, thereby avoiding sodium hypochlorite incidents. It is important to note that it is possible to create positive pressure in the pulp canal if the Master Delivery Tip is misused, which would create the risk of a sodium hypochlorite incident. The manufacturer's instructions must be followed for correct use of the Master Delivery Tip.

The RinsEndo system

The RinsEndo system irrigates the canal using pressure-suction technology developed by Durr Dental Co. 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.*[13] 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.

CONCLUSION

Various irrigation devices have been developed to give the effective cleaning and superior debris removal to replace the older needle irrigation method. Many clinical studies have reported the higher efficacy ineffective microbial count. However, there is no high level of evidence that correlates the clinical efficacy of these devices with better treatment outcomes. Nevertheless, due to the safety factors, capacity of high volume irrigant delivery and ease of application the newer irrigation devices may change the insight of conventional endodontic treatment.

REFERENCES

1. Gu LS, Kim JR, Ling J, Choi KK, Pashley DH, Tay FR, *et al.* Review of contemporary irrigant agitation techniques and devices. J Endod 2009;35:791-804.
2. Boutsioukis C, Gogos C, Verhaagen B, Versluis M, Kastrinakis E, Van der Sluis LW, *et al.* The effect of root canal taper on the irrigant flow: Evaluation using an unsteady computational fluid dynamics model. Int Endod J 2010;43:909-16.
3. Boutsioukis C, Gogos C, Verhaagen B, Versluis M, Kastrinakis E, Van der Sluis LW, *et al.* The effect of apical preparation size on irrigant flow in root canals evaluated using an unsteady computational fluid dynamics model. Int Endod J 2010;43:874-81.
4. 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.
5. Boutsioukis C, Verhaagen B, Versluis M, Kastri-nakis E, Van der Sluis LW. Evaluation of irrigant flow in the root canal using different needle types by an unsteady computa-tional fluid dynamics model. J Endod 2010;36:875-9.
6. Al-Hadlaq SM, Al-Turaiki SA, Al-Sulami U, Saad AY. Efficacy of a new brush-covered irrigation needle in removing root canal debris: A scanning electron microscopic study. J Endod 2006;32:1181-4.
7. Pesse AV, Warrier GR, Dhir VK. An experimental study of the gas entrapment process in closed-end microchannels. Int J Heat Mass Trans 2005;48:5150-65.
8. Schoeffel GJ. The endoVac method of endodontic irrigation, Part 2 – efficacy. Dent Today 2008;27:82, 84, 86-7.
9. Machtou P. Irrigation Investigation in Endodontics. Paris VII University, Paris, France: Masters Thesis; 1980.
10. Caron G. Cleaning Efficiency of the Apical Millimeters of Curved Canals using Three Different Modalities of Irrigant Activation: An SEM study. Paris VII University, Paris, France: Masters Thesis; 2007.
11. McGill S, Gulabivala K, Mordan N, Ng YL. The efficacy of dynamic irrigation using a commercially available system (RinsEndo) determined by removal of a collagen 'bio-molecular film' from an *ex vivo* model. Int Endod J 2008;41:602-8.
12. Huang TY, Gulabivala K, Ng YL. A bio-molecular film *ex-vivo* model to evaluate the influence of canal dimensions and irrigation variables on the efficacy of irrigation. Int Endod J 2008;41:60-71.

13. Wiggins S, Ottino JM. Foundations of chaotic mixing. Philos Trans A Math Phys Eng Sci 2004;362:937-70.
14. Ruddle CJ. Microbrush for Endodontic Use. Washington, DC: United States Patent 6, 179, 617; 2001.
15. Weise M, Roggendorf MJ, Ebert J, Petschelt A, Frankenberger R. Four methods for cleaning simulated lateral extensions of curved root canals: A SEM evaluation. Int Endod J 2007;40:991-2.
16. Setlock J, Fayad MI, Be Gole E, Bruzick M. Evaluation of canal cleanliness and smear layer removal after the use of the Quantec-E irrigation system and syringe: A comparative scanning electron microscope study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;96:614-7.
17. Walters MJ, Baumgartner JC, Marshall JG. Efficacy of irrigation with rotary instrumentation. J Endod 2002;28:837-9.
18. Walker TL, del Rio CE. Histological evaluation of ultrasonic and sonic instrumentation of curved root canals. J Endod 1989;15:49-59.
19. 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.
20. Carver K, Nusstein J, Reader A, Beck M. *In vivo* antibacterial efficacy of ultrasound after hand and rotary instrumentation in human mandibular molars. J Endod 2007;33:1038-43.
21. Tronstad L, Barnett F, Schwartzben L, Frasca P. Effectiveness and safety of a sonic vibratory endodontic instrument. Endod Dent Traumatol 1985;1:69-76.
22. Ahmad M, Ford TR, Crum LA. Ultrasonic debridement of root canals: An insight into the mechanisms involved. J Endod 1987;13:93-101.
23. Walmsley AD, Lumley PJ, Laird WR. Oscillatory pattern of sonically powered endodontic files. Int Endod J 1989;22:125-32.
24. 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.
25. Hu¨lsmann M, Hahn W. Complications during root canal irrigation: Literature review and case reports. Int Endod J 2000;33:186-93.
26. Nielsen BA, Baumgartner JC. Comparison of the endovac system to needle irrigation of root canals. J Endod 2007;33:611-5.
27. 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;109:479-84.
28. Gutarts R, Nusstein J, Reader A, Beck M. *In vivo* debridement efficacy of ultrasonic irrigation following handrotary instrumentation in human mandibular molars. J Endod 2005;3:166-70.
29. Klyn SL, Kirkpatrick TC, Rutledge RE. *In vitro* comparisons of debris removal of the endo activator system, the F file, ultrasonic irrigation, and NaOCl irrigation alone after handrotary instrumentation in human mandibular molars. J Endod 2010;36:1367-71.
30. Susin L, Liu Y, Yoon JC, Parente JM, Loushine RJ, Ricucci D, *et al.* Canal and isthmus debridement efficacies of two irrigant agitation techniques in a closed system. Int Endod J 2010;43:1077-90.

Source of support: Nil; Conflict of interest: None Declared