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Ultrasonic Irrigation- A Review

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Abstract: Debridement of the root canal system is an essential process for endodontic success. Irrigation is important part of root canal debridement. It is difficult to shape and clean the root canal completely because of the complex nature of root canal anatomy. Biomechanical preparation, pulp space sterilization and three-dimensional obturation are the hallmarks of endodontic success. Complete disinfection of the pulp space will be difficult to achieve with most limited instrumentation techniques. Optimal irrigation is based on the combined usage of two or more irrigating solutions, in a specific sequence. The aim of this article is to review newer irrigation systems in endodontic practice.

Key words: Ultrasonic activation, Piezoelectric generators, Endo Activator, Endo Vac, Negative pressure

INTRODUCTION

The success rate of endodontic procedure or treatment depends on the eradication of microbes, smear layer from the root canal and prevent re-infection. The root canal is cleaned and shaped using hand and rotary instruments with constant irrigation to remove the necrotic tissue and inflamed tissue, microbes or biofilm layer, and other debris from the root canal ¹. The main goal of instrumentation is to remove debris, inflamed or necrotic tissue from the root canal ². Sometimes instrumentation may not be enough for cleaning the root canal in such cases irrigants can be used. Irrigants can enhance mechanical debridement by flushing out debris, dissolving the tissue, and disinfecting the root canal. Teeth with complex internal anatomy such as fins or other irregularities that might be missed by instrumentation hence they need chemical debridement for successful root canal treatment ³. For an effective result of cleaning and shaping of root canal, an irrigant should be able to disinfect and penetrate dentin and its tubules, offer a long-term antibacterial effect that is; it should have substantivity, should remove the smear layer, and be non-antigenic, nontoxic and non-carcinogenic ⁴. It also should not have any adverse effects on dentin or the sealing ability of filling materials and it should also be relatively inexpensive, convenient to apply and cause no discoloration of tooth. An ideal irrigant include the ability to dissolve the pulp tissue and inactivate endotoxins that may or may not be present ⁵. Various irrigants such as saline, sodium hypochlorite (NaOCl), chlorhexidine digluconate (CHX), ethylenediaminetetraacetic acid (EDTA), hydrogen peroxide (H₂O₂), Maleic acid, hydroxyethylidene Bisphosphonate (HEBP), and natural irrigants are mostly used for root canal disinfection and smear layer removal ⁶. MTAD, Electrochemically activated solutions, Photon-activated disinfection, and Herbal irrigants are the newer root canal irrigants available in market ⁷. An endodontic irrigant should poses a broad antimicrobial spectrum, high efficacy against microorganisms present in biofilms, ability to dissolve the remnants of necrotic pulp tissue, ability to inactivate the endotoxin, ability to prevent the formation of a smear layer during instrumentation or to dissolve the latter once it has formed, systemically nontoxic when they come in contact with vital tissues, non-caustic to periodontal tissues, and with little potential to cause an anaphylactic reaction ^{3,5}. At present, there is no irrigant that combines all the ideal characteristics, even when they are used with a lower pH, increased temperature or added surfactants to increase their wetting efficacy ^{8,9}. In practice, current endodontic treatment uses two irrigants, sodium hypochlorite (NaOCl), alone or in combination with ethylenediaminetetraacetic acid (EDTA) or chlorhexidine. In endodontics, ongoing efforts have been made to develop more effective systems to send and agitate irrigant solutions in the canal system. These can be divided into two categories of manual and mechanical agitation techniques. Machine-assisted endodontic procedures include use of rotary brushes, rotary instrumentation with simultaneous irrigation of the canal, pressure alternation devices, sonic and ultrasonic systems. All of them appear to improve canal cleaning in comparison to conventional syringe and needle irrigation ¹⁰. Saline causes less apical tissue damage than other irrigants but the major disadvantage is very less dissolving property and antibacterial activity ¹¹. Sodium hypochlorite was used for treating wounds during World War I by a physician named Dakin. It was also called as Dakin's solution ¹². There are three different mechanism of action such as saponification reaction, amino acid neutralization reaction, chloramination reaction ¹³. Sodium chlorite acts as lubricant, solvent of pulp tissue, antiseptic, bleach according the concentration. Ethylenediamine tetracetic acid is a chelating agent. It is effective in softening dentin and has distinct antimicrobial properties thus it removes smear layer from root canal ¹⁴. Chlorhexidine gluconate is a biguanide. It poses a broad

spectrum antimicrobial action, substantivity and relative absence of toxicity. Usually 0.2% of chlorhexidine is used as irrigant. It causes cytoplasmic precipitation or coagulation on the cell wall ¹⁵.

Ultrasonic Irrigation

Richman in 1957 introduced ultrasonic instrumentation to endodontics for root canal treatment. Martin and Cunningham coined the term endosonic. Among all known irrigants, 5.25% Sodium hypochlorite has maximum efficiency upon ultrasonic activation. In combination there occurs heating of irrigant, removal of dentinal debris, movement into apical delta and lateral canals and greater cleaning effect. There are two types of ultrasonic irrigation. The first type is the simultaneous combination of instrumentation as well as ultrasonic irrigation. The second type is passive ultrasonic irrigation (PUI) which functions without simultaneous instrumentation ¹⁶. The first type is not followed much in the clinical practice, because of the difficulty of controlling the cut of dentin and subsequently the final shape of the prepared canal. When ultrasonic activated files are used in curved canals, there occurs canal deviations, apical zips and radicular perforations ¹⁷. Hence, therefore not considered as an alternative to conventional manual instrumentation¹⁸. Numerous successful devices have been developed for agitating irrigant solutions, that provide various irrigant transfer mechanisms, elimination of soft tissue and also, depending on the treatment philosophy, elimination of the smear layer. In comparison to sonic irrigation, ultrasonic irrigation have been proved to be more powerful and able to eliminate more debris, and so it is claimed that passive ultrasonic irrigation is significantly more efficient than sonic activation ¹⁹. However, both techniques may clean the canal system to a similar degree when sonic irrigation is applied for a longer time ²⁰. The capacity of irrigating solutions with good wetting ability to dissolve tissue can be improved by ultrasound if the pulp tissue debris and/or the smear layer are thoroughly moistened by the solution and it is subjected to ultrasonic agitation ⁷.

Ultrasonic Irrigation Devices:-

Many ultrasonic irrigation devices are available in market with development and extraordinary functioning capacities. They are designed and modified such that the function required to be done is established effectively.

Ultrasonic Activation:-

(Cavi Endo Dentsply International/York/PA/USA) is an ultrasonic system which has been designed first for both prophylaxis and endodontic therapy. It is a magnetostrictive ultrasound unit. The system has a switch, prophylaxis (or) endo mode selection switch, power control dial and water supply control dial along with LED indicators, Air pressure valve window. The Cavi-Endo instrument was reported to be successful in the removal of a broken bur tip and amalgam particles from the intracanal space.

Ultrasonic Activation (Osadaenac ENAC/USA) System:-

It is an ultrasonic endodontic unit designed based on the Quartz Piezoelectric vibrator system. It gets automatically tuned to provide stable 30KHz ultrasonic oscillation. This ultrasound system has a handpiece hose assembly along with holder, a foot switch and also water hose with filter and connector. The functions of this system are simultaneous root canal enlargement with U files and swirling irrigation for debridement, root canal obturation without water, restoration removal, flush cleaning of periodontal pockets and pits and fissures, root-end preparations using angled diamond coated files.

Continuous Ultrasonic Irrigation:-

It is a system designed to deliver continuous Piezo Flow Tulsa (OK/USA) irrigation. It provides excellent cleaning power by facilitating the introduction of irrigants into root canal structure, dentinal tubules and isthmuses. It can disrupt biofilms. It improves the action of sodium hypochlorite even if applied for 1 min. The nature of the vibration pattern of the activated file and the effectiveness of ultrasonic debridement is limited by the bedew the file against the root canal wall ²¹.

Mini Endo Piezoultrasonic Unit:-

It is an exclusively designed ultrasonic cleaning unit for endodontic applications. It is operated and controlled by microprocessors that are designed to deliver the exact amount of power and amplitude at the tip of the instrument to successfully complete the endodontic procedures.

Passive Ultrasonic Irrigation:-

PUI (IrriSafeSatelec (R&D), France) is a uniquely designed system that helps to remove the smear-layer and to kill the microorganisms, even in inaccessible areas or in curved canals. The advantage of this system is that it can be used safely without any risk of damaging the apical structure. Driven by the Newton range of piezoelectric generators, it generates micro-cavitation and microcurrents that spread through the canal system. IrriSafe is small, parallel-shaped and non-cutting (blunt-ended) and can therefore be used in the complete root canal. The

instrument with thinnest diameter is recommended for the majority of the clinical cases (IRR 20), the largest instrument can be used for the treatment of juvenile canals (IRR 25). The instrument should be allowed to vibrate freely inside the lumen of the root canal. IrriSafe is available in two lengths, from IRR20/21 or IRR20/25 and, IRR25/21 or IRR25/25. IrriSafe system is inserted inside the canal 2 mm short of the determined working-length and it can be pre-shaped, if necessary. 20 ml of the irrigant solution is injected into the root canal with a syringe. IrriSafe is activated for 10 seconds, at the recommended color coded power level the instrument is moved with a pull-stroke and backwards; it also drives the debris and the smear layer back to the surface ¹⁵.

Endoactivator System:-

Endo Activator(Dentsply Tulsa Dental Specialties) vigorously energize intracanal irrigants using sonic energy. It has strong, flexible medical grade uncoated and non-cutting polymer tips for Single patient use. It creates fluid hydrodynamics, improves debridement and the disruption of the smear layer and biofilm. The handpiece or driver has 3 speed sonic motor that provides low, medium, high speed accordingly ²².

Endovacsystem

EndoVacis considered as an apical negative pressure irrigation system which is composed of three basic components such as a Master Delivery Tip (MDT), Macrocannula, and Microcannula. The MDT component of the system delivers irrigant solution to the pulp chamber and evacuates the irrigant. Both the macrocannula and microcannula components are connected by tubing to a syringe of irrigant and also to the high speed suction of a dental unit. The macrocannula component of the system is made of flexible polypropylene with an open end of 0.55 mm in diameter, an internal diameter of 0.35 mm, and a 0.02 taper. These are used to suction irrigants up to the middle segment of the canal. Lastly, the microcannula component of the system 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 of the component 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 component also has a closed end with an external diameter of 0.32 mm that can be used in canals to enlarge the size to 35 or larger, and should be taken upto the determined working length (WL) to aspirate irrigants and debris. During irrigation, the MDT component delivers the irrigant to the pulp chamber and removes off the excess irrigant to prevent the overflow. The cannula in the canal simultaneously exerts negative pressure that pulls the irrigant from its fresh supply in the chamber by the MDT component into the cannula and out through the suction hose. Thus, a constant flow of fresh irrigant into the canal is being delivered by negative pressure till the determined working length. This particular system uses negative pressure in the apical terminus of the root canal to move the irrigation solution through negative pressure gradients ¹⁵.

CONCLUSION

Irrigation plays a key role in successful endodontic therapy. Use of sodium hypochlorite helps in achieving maximum chemomechanical debridement. Detailed understanding of the mode of action and mechanism irrigation devices is critical for the use and optimal irrigation. The combination of conventional irrigation together with ultrasonic irrigation facilitates the procedure and improves the elimination of bacteria and the smear layer throughout the canal system thereby contributing to higher success rates for endodontic treatment.

CONFLICT OF INTEREST

Conflict of interest declared none.

REFERENCES

1. Markus Haapasalo, Ya Shen, Wei Qian, Yuan Gao. Irrigation in Endodontics. Dent Clin N Am, 2010; 54: 291–312.
2. Peters OA, Schonenberger K, Laib A. Effects of four Ni-Ti preparation techniques on root canal geometry assessed by micro computed tomography. IntEndod J 200; 34:221–30.
3. DeivanayagamKandaswamyand NagendrababuVenkateshbabu. Root canal irrigants. J Conserv Dent. 2010 Oct-Dec; 13(4): 256–264.
4. Torabinejad M, Handysides R, Khademi A, Bakland LK. Clinical implications of the smear layer in endodontics: A review. Oral Surg Oral Med Oral Pathol Oral RadiolEndod 2002; 94:658-66.
5. Zehnder M. Root canal irrigants. J Endod 2006; 32:389-98.
6. Amit Jena, Sanjit Kumar Sahoo and ShashirekhaGovind. Root Canal Irrigants: A Review of Their Interactions, Benefits, and Limitations. Compendium, 2015; 36(4): 174-180.

7. Spangberg L, Engstrom B, Langeland K. Biological effect of dental materials. Toxicity and antimicrobial effect of endodontic antiseptics in vitro. *Oral Surg Oral Med Oral Pathol.* 1973; 36(6):856-871.
8. Briseno BM, Wirth R, Hamm G, Standhartinger W. Efficacy of different irrigation methods and concentrations of root canal irrigation solutions on bacteria in the root canal. *Endod Dent Traumatol.* 1992;8:6-11.
9. Al-Jadaa A, Paqué F, Attin T, Zehnder M. Acoustic hypochlorite activation in simulated curved canals. *J Endod.* 2009; 35:1408-11.
10. Gu LS, Kim JR, Ling J, Choi KK, Pashley DH, Tay FR. Review of contemporary irrigant agitation techniques and devices. *J Endod.* 2009;35:791-804.
11. Abbott PV, Heijkoop PS, Cardaci SC, Hume WR, Heithersay GS. An SEM study of the effects of different irrigation sequences and ultrasonics. *IntEndod J.* 1991; 24:308-16.
12. Klyn SL, Kirkpatrick TC, Rutledge RE. in vitro comparison of debris removed of the Endoactivator System, the F File, ultrasonic irrigation, and NaOCl irrigation alone after hand rotary instrumentation in human mandibular molars. *J Endod.* 2010;36:1367-71.
13. van der Sluis LW, Versluis M, Wu MK, Wesselink PR. Passive ultrasonic irrigation of the root canal: a review of the literature. *IntEndod J.* 2007;40:415-26.
14. van der Sluis LW, Wu MK, Wesselink PR. A comparison between a smooth wire and a K-file in removing artificially placed dentine debris from root canals in resin blocks during ultrasonic irrigation. *IntEndod J.* 2005;38:593-6.
15. Susila A, Minu J. Activated Irrigation vs. Conventional non-activated Irrigation in Endodontics – A Systematic Review. *EurEndod J,* 2019; 3: 96-110.
16. Desai P, Himel V. Comparative safety of various intracanal irrigation systems. *J Endod.* 2009; 35:545-9.
17. Shahidshujaqaz, manzooraahmedmanzoor, rizwanqureshi, hannanhumayun khan. Comparison of postoperative pain — normal saline vs sodium hypochlorite as irrigants. *Pakistan Oral & Dent. Jr.* 2005; 25(2): 177-182.
18. McKenna SM, Davies KJ. The inhibition of bacterial growth by hypochlorous acid. Possible role in the bactericidal activity of phagocytes. *Biochem J.* 1988; 254(3):685-692.
19. McComb D, Smith DC, Beagrie GS. The results of in vivo endodontic chemomechanical instrumentation—a scanning electron microscopy study. *J Br Endod Soc.* 1976;9(1):11-18.
20. Davies GE, Francis J, Martin AR. 1:6-Di-4'-chlorophenyldiguanidohexane (hibitane); laboratory investigation of a new antibacterial agent of high potency. *Br J PharmacolChemother.* 1954; 9(2):192-196.
21. Reddy S, Venkatesh A, Geethapriya N, Subbiya A. Ultrasonic Tips in Surgical and Non Surgical Root Canal Therapy: A Review of Literature. *Indian Journal of Public Health Research & Development.* 2019;10(12):2182-5.
22. Venkatesh A, Mary GP, Selvakumar N, Subbiya A. Recent advances in endodontic irrigation devices. *European Journal of Molecular & Clinical Medicine.* 2020;7(3):2110-4.