Review Article

Types of needles used in the irrigation of root canal system - A review

G. Nithya Karpagam[1], James David Raj[2]*

ABSTRACT

The aim of this study is to review about the types of needles used in irrigation of root canal systems. The main objective is to review about the different types of needles used in irrigation of root canals and their advances in root canal treatment. Bacteria in the root canal systems help in the formation of periapical inflammatory lesions. The main aim of root canal treatment is to eliminate these microbes from the infected root canal and prevent reinfection. Irrigants are delivered to root canal space using syringes and metal needles of different gauges and design. To increase the efficiency of irrigants delivered by syringe, different types of needles have been used. There is still no consensus regarding the superiority of any of the types of needles. To review the knowledge regarding the various types of needles used in irrigation of root canal system.

KEY WORDS: Irrigation, Needles, Root canal, Types

INTRODUCTION

Endodontics is the branch of dentistry that is concerned with the morphology, physiology, and pathology of the human dental pulp and periradicular tissues. Its study and practice encompass the basic clinical sciences including biology of the normal pulp; the etiology, diagnosis, prevention, and treatment of diseases; and injuries of the pulp and associated conditions. The endodontists are having the responsibility of the advancement of knowledge through studies and research and the spread of advances made in the specialty of endodontics and education of people about the importance of endodontic treatments and procedures to create awareness among them to maintain a proper oral health.

The instrumentation and irrigation of the root canal are done to clean and disinfect the root canal which comprises the endodontic therapy.[1] In the irrigation technique, the chemical solutions are used to lubricate the walls of the canal, remove debris, dissolve organic tissues, and eliminate bacteria. Moreover, the mechanical devices are utilized to carve and shape the root canal to allow the chemical solution to enter the root canal efficiently. The endodontic microorganisms have been found to be greatly eliminated by the mechanical action of irrigation.[2]

Different irrigation needles and gauges have been used by the dentists in root canal treatment. However, the effectiveness varies with every needle. This is due to the ability of the needles to reach the apical third and deliver the solution to the full working length of the root canal.[3-5]

In a study, it was shown that, irrespective of the tip design, the optimal sized needle was more effective in cleaning the apex. These results were previously reported in another study in which radiopaque medium was mixed with dentin shavings.[6] In another study by Hsieh, the usage of large diameter needles could have an adverse effect on the flow of the irrigants in the root canal.[7]

Two or more irrigating solutions have been used in a specific sequence to obtain effective irrigation. Irritants are delivered into the root canal conventionally by the needles of various sizes and tip design. According to many researchers, this could result in ineffective irrigation, particularly in the apical region of root canal and anastomoses around the apex due to

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

[1]Department of Endodontics, Saveetha Dental College, Saveetha University, Chennai, Tamil Nadu, India, [2]Department of Endodontics, Saveetha Dental College, Saveetha University, Chennai, Tamil Nadu, India

***Corresponding author:** Dr. James David Raj, Department of Endodontics, Saveetha Dental College, Saveetha University, 162, Poonamallee High Road, Chennai - 600 077, Tamil Nadu, India. Phone: +91-9789043634. E-mail: jamesdraj@gmail.com

Received on: 05-06-2018; Revised on: 08-07-2018; Accepted on: 09-08-2018

inability of the tips to reach the full working length. Hence, various chemical irritants have been developed and combined and several mechanical instruments have been developed to improve the penetration and effectiveness.

25-gauge (25-G) needles were used commonly a few years ago, but then they were replaced by 27-G needles and then now by 30-G and 31-G needles, which have been used routinely. Mostly, smaller needles are preferred. Researchers have found that the chemical agents have only a limited effect beyond the tip of the needle as the air in the apex prevents the solution to reach the apical tip, hence preventing effective cleansing. However, smaller needles allow the solution to enter the apex of root canal but with safety concerns. Several modifications of the needle-tip designs have been introduced in recent years to facilitate effectiveness and minimize safety risks.

There are few comparative data about the effect of needle design on the effectiveness of irrigation. It is hoped that ongoing computational fluid dynamics (CFD) and clinical studies will change this situation.

This review will show some lights on the types of needles used in irrigation technique, efficacy of those needles, and procedures for safe and efficient irrigation and provides cutting-edge information on the most recent developments.

IRRIGATION TECHNIQUES

The endodontic treatment includes eradication of microbes from the root canal system and prevents the infection from reoccurrence. The significance of instrumentation lies in facilitating the effective irrigation, disinfection, and filling the space. Several studies demonstrated that a large proportion of root canal space remains unaffected by the instruments. Hence, the need for using the chemical agents to cover areas untouched by the instruments. Optimal irrigation could be achieved by combining two or more chemical irrigating solution in a specific order to attain the goals of irrigation with proper safety and effectiveness. Figure 1a, 1b and 1c shows different sizes of syringes used to deliver the irrigants. A small-sized syringe has been recommended in treatments as it is easy to use and less frequently refilling during

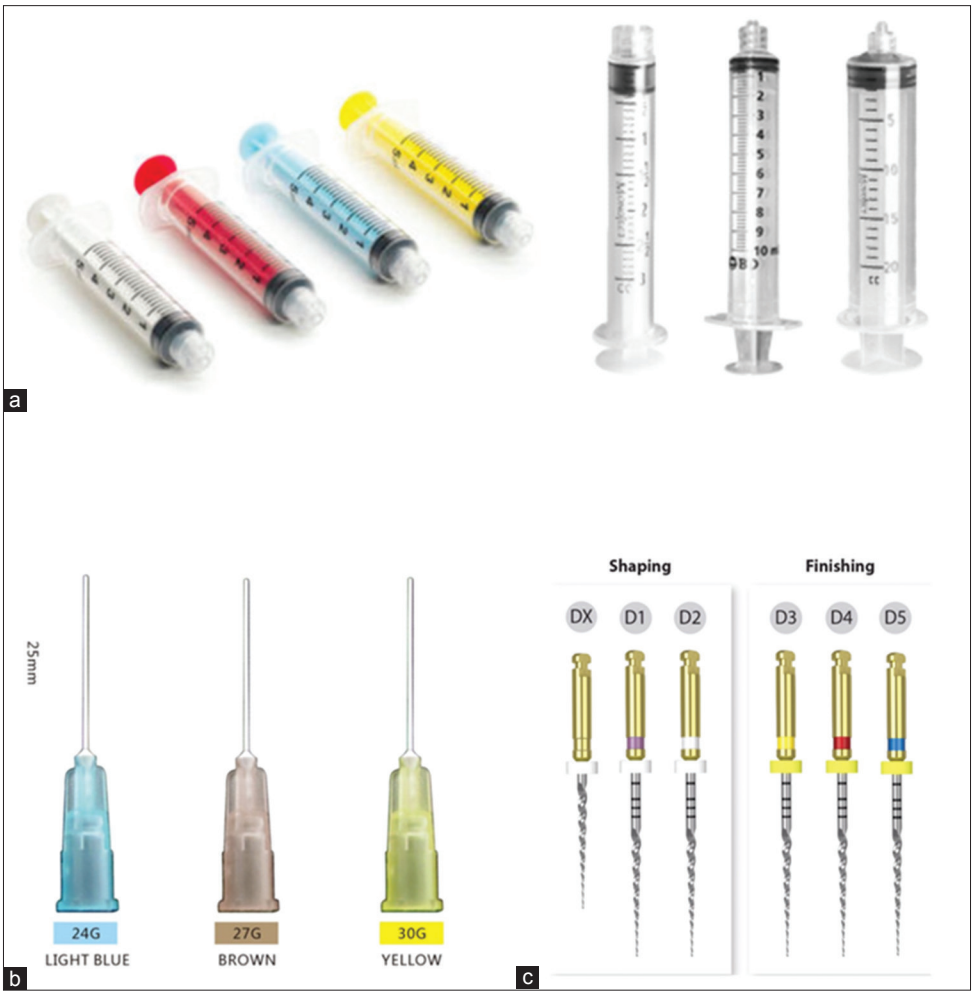

Figure 1: (a) Different sized and colored syringes used in irrigation of root canals. (b) Endo irrigation needles. (c) Rotary files to shape the root canals

procedure. When needed more irrigation, large-sized 20 mL syringes can be used. A Luer Lock threaded fitting is always present in the endodontic syringes. It is necessary to avoid accidental detachment of the needle during irrigation which occurs due to the development of very high pressure inside the syringe.

IDEAL REQUIREMENTS OF IRRIGANTS

Irrigants are the chemical solution which are delivered into root canals to dissolve the tissue remnants, eradicate the microorganisms, and clean the root canal effectively and safely without any consequences. The ideal irrigant solution should have the following properties:

1. It should have the broad antimicrobial action.
2. It should be able to dissolve the necrotic pulp remnants.
3. It should inactivate the endotoxins.
4. It should have greater efficacy against the facultative and anaerobic organisms.
5. It should be able to prevent the smear layer from forming during instrumentation and to dissolve the smear layer if formed.
6. It should be non-toxic to the system and vital tissues and should not cause pain in periodontal tissues and little anaphylactic property.

INSTRUMENTS FOR IRRIGATION

Irrigants have been delivered into the root canal space using syringes and metal needles which have been sophisticatedly made into different size and tip design. However, this approach does not result in effective irrigation, especially in the apical areas and anastomoses between the canals. Hence, many agents have been modified and several mechanical devices have been developed to improve the effectiveness of irrigation. Figure 2[6,8-10] shows different needle designs based on the computerized model; A - flat, B - beveled, C - notched, D - side vented, E - double side vented, F - multivented.

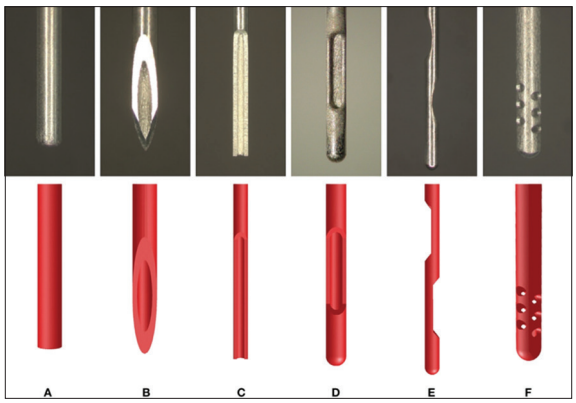

Figure 2: (a-f) Different needle designs being implemented in root canal irrigation. True and virtual designs based on computerized models

NEEDLES USED IN ENDODONTIC TREATMENT

Needles were used to deliver the irrigants into the canal. In the study by Boutsioukis *et al.*,[10] 30-G commercial needles were used as references. The images of these needles used in his study are shown in Figure 2, and the 3D models were created based on the computerized virtual designs. Six different needle designs were utilized in his research. These needles could be divided into two groups. Of the six, three needles (A, B, and C) were open-ended needles and three needles (D, E, and F) were closed-ended needles. The diameter and lengths of all these needles were standardized to separate only the effects of the tip designs. All the needles were placed inside the root canal at 3 mm short of working length to avoid extrusions and to attain a standardized effect.

In this study, it was found that to remove debris and other materials completely. Side vented needles is not that much effective in irrigation system. This finding had been reported in other studies. However, previously, it was believed that the side-vented needles were more effective than the open-ended needles in the exchange of the irrigants in the root canal. However, this study contradicted in that way. Furthermore, among the open-ended needles, there was no significant advantage between the flat and beveled or notched needles. Only that they posed some consequences in terms of causing injury such as wedging in the canal, due to their shaping. Among the side-vented needles, the effectiveness was more along the walls facing the vents, and there was no significance found between the side-vented and double side-vented needles.

This study suggested that all the needle designs created a higher sheer pressure near the tip of the needle which indicated higher mean pressure in the apical foramen which would cause the extrusion more likely. The clinical point requires the avoidance of extrusion to be the primary concern than the effectiveness and the irrigants replacement and sheer pressure.

Different kinds of needle gauges and designs may affect the effectiveness of irrigation. In a research, it had been reported that 30-G needles were more efficacious in cleaning the apical areas of root canal. Piccinino and Abou-Ross[6] reported similar results from a study in which radiopaque medium was mixed with dentin shavings and injected into the root canals of extracted mandibular molars. Hsieh[7] demonstrated that the flow of root canal irrigation could be adversely affected by the use of large diameter needles using the thermal image analysis.

In a study, the results showed that 30-G needles could reach out to get close to the working length, improving efficacy. On the other hand, 23-G needle could not penetrate deeply into the root canal and hence could not allow adequate cleaning.[11] Hence, it was confirmed that smaller size could not be the best option in reaching the deeper most part of the root canal.

ANTIBACTERIAL IRRIGATING SOLUTIONS

The irrigation solution plays a vital part in endodontic treatment. The irrigants facilitate the removal of debris, necrotic tissues, dentin chips, and microorganisms from the root canal by the flushing action. Irrigants can dissolve the organic and inorganic tissues in the root canal. Many irrigating chemical solutions have the antibacterial activity by eradicating bacteria and antifungal ability by killing the yeasts when they are coming in contact with the microorganisms. However, the disadvantages of these irrigating solutions are the cytotoxic activity exhibiting by them and causing severe pain in the periapical areas if they enter beyond the apical root canal. An optimal irrigant is said to have most or all of the positive properties and does not exhibit any of the negative properties. There is no optimal irrigant presently. However, when two or more solutions are combined together in a selected manner, it could result in a potentially successful treatment. We will see more about the properties of different irrigants below.

NaOCl

NaOCl is the most widely used irrigating solution. It ionizes in water to form Na+ and OCl- ions. The hypochlorite ion OCl- forms an equilibrium with hypochlorite acid, HOCl. HOCl is the active agent, which is responsible for the inactivation of bacteria in root canal. It is a very potent antimicrobial agent and can dissolve pulp remnants and dentin remains. It has the ability to kill the bacteria at very low concentration. Waltimo et al. showed that it can kill the bacteria *in vivo* in 30 s. The disadvantages of NaOCl are its unpleasant taste, inability to remove the smear layer due to lacking the effect on inorganic materials, and its toxicity. It shows the poorer effect on microbes *in vivo*. This is due to the anatomy of root canal, especially inability to reach the apical region. Many studies showed the NaOCl exhibited higher cytotoxicity and could cause damage to healthy tissues. This, entering into the periapical areas, could cause severe pain. The toxic effect and the complications are the main reason for using this solution in low concentrations which could delay the effect and could also have lower effect on microbes. Hence, more studies are needed to be conducted in endodontic infections and treatment modules using NaOCl solution for deeper understanding on the properties of this solution.

ETHYLENEDIAMINETETRAACETIC ACID (EDTA), CITRIC ACID, AND OTHER ACIDS

EDTA has very low antibacterial effect. EDTA releases some of the surface proteins on exposure for longer time. This could lead to bacterial death. EDTA is an efficient chelating agent in root canal. It removes smear layer when combined with NaOCl. Hence, by cleaning and removing the infected tissue, it eliminates bacteria in the root canal. It has been reported that removal of the smear layer improves the antibacterial effect of irrigating agents. When comparing with the ultrasound, 10% citric acid were more effective in removing the smear layer from the root ends. A comparative study showed that 10% citric acid was more effective than 1% citric acid, which was more effective than EDTA in demineralizing dentin. The researchers also found that the CO_2 laser was effective in the removal of smear layer and Er:YAG laser was more effective than the CO_2 laser. Smear should be removed effectively to give access to the irrigants into the root canals deeper structures, hence enhancing the disinfection. Both EDTA and citric acid can effectively remove the smear layer when used together with NaOCl. Citric acid and EDTA may have weak antimicrobial activity as standalone products. However, their antimicrobial effectiveness has not been extensively documented and appears to be of minor importance.

Hydrogen Peroxide (H_2O_2)

H_2O_2 is a biocides used to sterilize and disinfect. It is more efficient against the Gram-positive bacteria. It is used in endodontics due to its cleansing property. It makes other disinfectants such as iodine more effective. It was used to clean the pulp chamber to clear away the blood and tissue remnants. It had been used as an irrigant, but the effectiveness is little comparing other irrigants.

Chlorhexidine Digluconate (Chx)

CHX is used as a disinfectant due to its antimicrobial property. It has been popular in endodontics as an irrigating solution and intracanal medicaments. NaOCl has a bad smell. However, CHX has no smell and it is not irritating like NaOCl. It has an effective antimicrobial action. However, the disadvantage comes as a complete lack of the ability to dissolve the tissue remnants. CHX is used as an anti-infective agent in antiseptic products. CHX causes coagulation of intracellular components in higher concentrations. Although it exerts a good antimicrobial property, the activity is mainly dependent on the pH and is greatly reduced in the presence of organic matter. CHX is more effective against Gram-positive than Gram-

negative bacteria. Mycobacteria and bacterial spores are resistant to CHX. CHX is not very effective against viruses.

ANTIBIOTIC-CONTAINING IRRIGATION SOLUTIONS

Mixture of tetracycline isomer, acid, and detergent (MTAD) is a MTAD. It is a new generation combination product for root canal irrigation. Tetraclean is another combination product similar to MTAD. MTAD has low pH due to the presence of citric acid. It removes smear layer and has antimicrobial activity. The main advantages are that it combines smear layer removal activity with the antimicrobial activity. It has low effect on the dentin than the EDTA. In a study, the author reported after the usage of 1.3% NAOCl during instrumentation, to use MTAD to remove smear layer. MTAD has the ability to solubilize dentin, and organic pulp layer is unaffected. MTAD is less cytotoxic than eugenol, but more cytotoxic than 2.63% NaOCl. Mate contains doxycycline in higher concentration which is responsible for antibacterial activity. The antibacterial activity is only due to the presence of antibiotic in it, but it lacks the effectiveness when combined with other compounds.

DEVELOPMENTS

Using the conventional needles to clean the apical third of the root canal is a challenge. Studies show the difficulty in removing the debris in this region.[5,12] New techniques and devices have been developed to attain the maximal efficacy in cleaning the apical area, such as RinsEndo and EndoVac systems.[13] These devices use the pressure suction technology. However, in a research, the report suggested that there is no significant difference in cleaning capacity on RinsEndo and conventional irrigation with syringe and 30-G needles. Figures 3 and 4 show the model of EndoActivator and EndoVac, respectively.

Highly sophisticated and expensive passive ultrasonic irrigation has been developed to improve the penetration of solution into the root canal.[14] Some researches showed that the irrigant solutions have been delivered by extrusion through the periapical tissues.[15] To deliver the solution through periapical areas, needles with side opening have been developed to minimize the risk of tissue damage.[16,17] Side opening needles and apical opening needles had shown similar results in cleaning the apical portion for all root canal widening. However, Kahn *et al*.[16] reported that side opened closed-end needles were more effective than the conventional needles. However, the researchers used red food dyes in clear plastic blocks and artificial root canals.

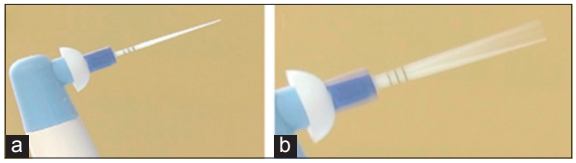

Figure 3: (a) Endo activator with large plastic tip. (b) Same tip in sonic motion

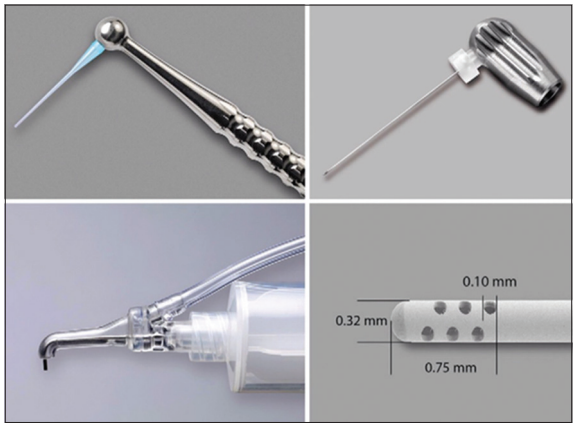

Figure 4: EndoVac system uses negative pressure to make safe and effective irrigation of the most apical canal of the root possible. The irrigant in the pulp chamber is sucked down into the root canal and sucked back again through the needle, contrary to the classic method of irrigation

In another study done by Usman, it was demonstrated that the needles performed better in root canals widened with a size of 40-K file, but the difference between the others was not significant. This lack of significance could be related to the coronal pre-flaring performed previously in all teeth. Albrecht[18] used nickel-titanium rotary instruments, and in his study, he had reported that debris was more effectively removed when apical preparation size was larger. However, when instruments with larger taper were used, there was no difference between the two preparation sizes.

Adopted irrigation speed of 5 mL/min was based on the study of Boutsioukis *et al*.[19] This study concluded that the needles with smaller diameter require increased current force. However, excessive speed and force should be avoided during irrigation due to the risk of apical extrusion.

CFD is a relatively new approach to improve the study and understanding of the actions in the root canal. CFD is a science that studies the predictable pattern of fluid flow and related phenomena by solving the mathematical equations that govern these processes. Theoretical and experimental studies were implemented to increase the understanding and have the realistic advantage in adopting the flow in the canal. CFD can be used to predict and evaluate the streamline flow, velocity, pressure, street on the walls. These are impossible to measure *in vivo* due to the

anatomy of root canals. The optimal turbulence model cannot be universally approved as being superlative in action. Each model has its strength and weakness. In CFD studies, the use of an unsuitable turbulence model may lead to potential numerical errors in CFD results.

Recent researches using CFD model, Figure 5,[6,8] have shown that the design of the needle tip affects the irrigant flow pattern and speed, resulting in pressure in the apical region.[17,20] However, the modified needle tips reduced to their pressure at the apical region minimizing the risk of extrusion of solution into the periapical tissues.

MAX-I PROBE

Max-I probe's tip design has improved efficacy, patient comfort, and safety when irrigating root canals and periodontal pockets. It is the tip that makes the difference. Sharp ended needles can go beyond the periapical region when perforated through the tissues. However, the round-ended tips in Max-I probe and side-vented model maximize the efficacy and patient safety. It prevents the apical penetration. The side port prevents solution and debris from being expressed through the apical foramen. It has an unique upward turbulent motion which exerts upward pressure to clear away the debris. Rounded tip prevents the risk of perforating the apex. The side-port opening provides full cleansing of the periodontal pocket by carrying particles upward and toward the crown. The rounded tip design eliminates the risk of tissue damage. It is available in 23G, 25G, and 30G.

VIBRINGE

The vibringe is the first endodontic sonic irrigation system that enables delivery and activation of the irrigation solution in the root canal in single step. The activation of the disinfectant by acoustic streaming enriches and completes the irrigation procedure and improves the success rate of endodontic treatments. This device system significantly improves the removal of debris. It disrupts the smear layer and biofilm by activating the irrigants. Vibringe needles saves time by providing powerful irrigation to remove debris and thereby removing the blockages, air in the canal.

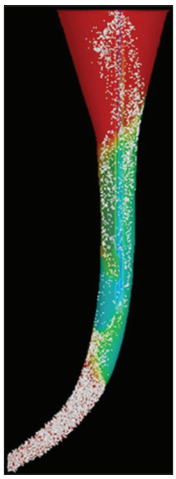

Figure 5: Particle tracking during irrigation stimulated by computational fluid dynamics model

CONCLUSION

Hence, new technologies are being developed which will pave a way to obtain the maximal effectiveness in irrigation. From the studies and authors' explanations, it may be concluded narrow needles are useful for removing debris from the apical portion 6. Large needles are not efficient enough to clean the apical area of the root canal. Needles having side or apical venting do not differ in performances. It is essential to understand the functions and actions of the irrigant solutions to attain the optimal irrigation.

New technologies such as CFD and various mechanical devices have been developed to advance the understanding in obtaining the safe and effective irrigation. The needle designs have been modified to minimize the risk of irrigant extrusion beyond the root apex. Many novel needles and several tip designs such as endoactivator, Max-I Probe, vibringe, RinsEndo, and Endovac are being developed to tackle the challenges of irrigation effectively. Our understanding of the irrigation has gone to a new level, but still further studies have to be done to attain the optimal irrigation.

REFERENCES

1. Lin LM, Skribner JE, Gaengler P. Factors associated with endodontic treatment failures. J Endod 1992;18:625-7.
2. Berber VB, Gomes BP, Sena NT, Vianna ME, Ferraz CC, Zaia AA, *et al.* Efficacy of various concentrations of NAOCl and instrumentation techniques in reducing *Enterococcus faecalis* within root canals and dentinal tubules. Int Endod J 2006;39:10-7.
3. Goldman M, Kronman JH, Goldman LB, Clausen H, Grady J. New method of irrigation during endodontic treatment. J Endod 1976;2:257-60.
4. Moser JB, Heuer MA. Forces and efficacy in endodontic irrigation systems. Oral Surg Oral Med Oral Pathol 1982;53:425-8.
5. Kahn FH, Rosenberg PA, Gliksberg J. An *in vitro* evaluation of the irrigating characteristics of ultrasonic and subsonic handpieces and irrigating needles and probes. J Endod 1995;21:277-80.
6. Abou-Rass M, Piccinino MV. The effectiveness of four clinical irrigation methods on the removal of root canal debris. Oral Surg Oral Med Oral Pathol 1982;54:323-8.
7. Hsieh YD, Gau CH, Kung Wu SF, Shen EC, Hsu PW, Fu E, *et al.* Dynamic recording of irrigating fluid distribution in root canals using thermal image analysis. Int Endod J 2007;40:11-7.
8. 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.
9. Usman N, Baumgartner JC, Marshall JG. Influence of instrument

size on root canal debridement. J Endod 2004;30:110-2.
10. Vivan RR, Bortolo MV, Duarte MA, Moraes IG, Tanomaru-Filho M, Bramante CM, *et al.* Scanning electron microscopy analysis of rinsEndo system and conventional irrigation for debris removal. Braz Dent J 2010;21:305-9.
11. Munoz HR, Camacho-Cuadra K. *In vivo* efficacy of three different endodontic irrigation systems for irrigant delivery to working length of mesial canals of mandibular molars. J Endod 2012;38:445-8.
12. Zairi A, Lambrianidis T. Accidental extrusion of sodium hypochlorite into the maxillary sinus. Quintessence Int 2008;39:745-8.
13. Kumar TS, Kavitha S, Lakshminarayanan L, Gomathi NS, Kumar V. Influence of irrigating needle-tip designs in removing bacteria inoculated into instrumented root canals measured using single-tube luminometer. J Endod 2007;33:746-8.
14. Albrecht LJ, Baumgartner JC, Marshal JG. Evaluation of apical debris removal using various sizes and tapers of ProFile GT files. J Endod 2004;30:425-8.
15. Boutsioukis C, Verhaagen B, Versluis M, Kastrinakis E, Wesselink PR, van der Sluis LW, *et al.* Evaluation of irrigant flow in the root canal using different needle types by an unsteady computational fluid dynamics model. J Endod 2010;36:875-9.
16. Shen Y, Gao Y, Qian W, Ruse ND, Zhou X, Wu H, *et al.* Three-dimensional numeric simulation of root canal irrigant flow with different irrigation needles. J Endod 2010;36:884-9.
17. Baratto-Filho F, de Carvalho JR Jr. Fariniuk LF, Sousa-Neto MD, Pécora JD, da Cruz-Filho AM, *et al.* Morphometric analysis of the effectiveness of different concentrations of sodium hypochlorite associated with rotary instrumentation for root canal cleaning. Braz Dent J 2004;15:36-40.
18. Pasricha SK, Makkar S, Gupta P. Pressure alteration techniques in endodontics - A review of literature. J Clin Diagn Res 2015;9:ZE01-6.
19. Van Ertbruggen C, Corieri P, Theunissen R, Riethmuller ML, Darquenne C. Validation of CFD predictions of flow in a 3D alveolated bend with experimental data. J Biomech 2008;41:399-405.
20. Gao Y, Haapasalo M, Shen Y, Wu H, Li B, Ruse ND, *et al.* Development and validation of a three-dimensional computational fluid dynamics model of root canal irrigation. J Endod 2009;35:1282-7.

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