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ORIGINAL RESEARCH

Current Trends in Irrigation Practice during Endodontic Treatment among Dental Practitioners in Nellore Urban Area: A Survey

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ABSTRACT

Aim: The purpose of this study was to determine the current trends in irrigation practice among the practicing dentists in Nellore urban area of Andhra Pradesh, India.

Materials and methods: A self-prepared questionnaire comprising 20 questions was given to 150 dentists practicing in Nellore urban area. The information gathered was the individual irrigant selection, irrigant concentration, smear layer removal, and use of adjuncts to irrigation, gauge of needle, tip design of needle, depth of needle penetration, volume of the syringe used, volume of irrigant used, duration of irrigation, choice of irrigant in vital teeth, teeth with radiographic evidence of periapical lesion, and retreatment cases.

Results: Our data indicated that majority of respondents (55.6%) are using saline as primary irrigant at a concentration of 0.9% whereas 44.4% of respondents primarily use sodium hypochlorite (NaOCl), with 51.4% of them using it at a concentration of 2.6 to 4%. Twenty-six gauge needle with single-beveled tip design being most preferred for syringe irrigation. Only 59.7% of respondents aimed to remove the smear layer during endodontic treatment with only 11.9% using an adjunct to irrigation.

Conclusion: Regardless of the critical nature of the irrigation step in the endodontic therapy, the results from the study were not satisfying, especially when it comes to the use of primary irrigant, adjuncts, or newer irrigating systems. Thus there is a need to regularly update and check the practices adopted by dental practitioners.

Keywords: Irrigation protocol, Needle gauge, Saline, Sodium hypochlorite, Survey.

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INTRODUCTION

The success of endodontic treatment depends primarily on the eradication of microorganisms from the root canal system and prevention of their reinfection.[1] Even with modern techniques that use nickel–titanium files, more than 35% of the root canal's surface can be left uninstrumented after nonsurgical root canal treatment.[2] To remove debris and address these uninstrumented surfaces, it is necessary to copiously irrigate the root canal and help by killing microorganisms, flushing debris, and removing both the organic and inorganic portions of the smear layer from the root canal system.[3] However, there is no single irrigating solution that alone sufficiently covers all the functions required for an irrigant.

Some irrigating solutions dissolve either organic or inorganic tissue in the root canal. In addition, several irrigating solutions have antimicrobial activity and actively kill bacteria and yeasts when introduced in direct contact with the microorganisms. At the same time, several irrigating solutions also have the cytotoxic potential, and they may cause severe pain if they gain access into the periapical tissues.[4]

The most widely used endodontic irrigant is 0.5 to 6.0% sodium hypochlorite (NaOCl), because of its bactericidal activity and ability to dissolve vital and necrotic organic tissue.[5,6] However, NaOCl solutions exert no effects on inorganic components of smear layer. Chelant and acid solutions have been recommended for removing the smear layer from instrumented root canals, including ethylene diaminetetraacetic acid (EDTA), citric acid, and phosphoric acid.[7]

Ethylene diaminetetraacetic acid is effective for removing the inorganic component of the smear layer. In an effort to improve the delivery and effectiveness of irrigants, different adjuncts have been developed. Both sonic and ultrasonic agitation of the irrigant has been studied for their ability to improve canal cleanliness. Systems, such as EndoVac (Discus Dental, Culver City, CA) use negative pressure to safely bring irrigants into contact with all surfaces of the root canal.[8]

Although many different irrigants and treatment protocols have been studied, little research has been conducted to determine the widespread practice or

acceptance of such methods and materials among General Dental Practitioners (GDPs). So the present survey was conducted to ascertain the current trends in irrigation among dental practitioners in Nellore urban area, Andhra Pradesh.

MATERIALS AND METHODS

A self-prepared questionnaire was personally given to a total of 150 dentists practicing in Nellore urban area, Andhra Pradesh, India. The questionnaire (Table 1) was made up of 20 questions with multiple-choice answers covering all the aspects of irrigation protocol in endodontics, including the variables which are not covered in previous surveys (Table 2).[1,9-19] A total of 150 dental clinics were personally visited and questionnaire form was given by hand. Among them 144 forms were completely filled and successfully collected, obtaining a response rate of 96%.

Table 1: Questionnaire

Name:	Qualification:
Age: Sex:	Specialty:
1. From how many years are you practicing endodontic therapy?	
(a) >30	(d) 5–10
(b) 21–30	(e) <5
(c) 11–20	(f) Still in training
2. Which irrigants do you use? (Please select all that apply)	
(a) Sodium hypochlorite	(e) EDTA
(b) Chlorhexidine	(f) MTAD
(c) Saline	(g) Citric acid
(d) Sterile water	(h) Other
3. Which irrigant do you primarily use?	
(a) Sodium hypochlorite	(e) EDTA
(b) Chlorhexidine	(f) MTAD
(c) Saline	(g) Citric acid
(d) Sterile water	(h) Other
4. Which concentration of NaOCl do you primarily use?	
(a) <0.5%	(e) 4.1–5.0%
(b) 0.5–1.5%	(f) >5.0%
(c) 1.6–2.5%	(g) I do not use NaOCl
(d) 2.6–4.0%	
5. Which concentration of chlorhexidine do you primarily use?	
(a) 0.2%	(d) >2.0%
(b) 0.18–1.9%	(e) I do not use chlorhexidine
(c) 2.0%	
6. How much volume of irrigant do you employ per canal?	
(a) 0.5 mL	(c) 5–10 mL
(b) 2.5 mL	(d) >10 mL
7. Rank the reasons for your primary irrigant selection from most important to least important.	
(a) Antibacterial capability	(d) Substantivity
(b) Biocompatibility	(e) Expense
(c) Tissue dissolution	
8. Do you routinely aim to remove the smear layer?	
(a) Yes	
(b) No	
9. Does your choice of irrigant(s) differ based on the pulpal or periapical diagnosis?	
(a) Yes	
(b) No	
10. Which of the following irrigants would you primarily utilize when treating a tooth with a vital pulp?	
(a) Sodium hypochlorite	(d) Sterile water
(b) Chlorhexidine	(e) Other
(c) Saline	

(Contd…)

(Contd…)

11. Which of the following irrigants would you primarily utilize when treating a tooth with radiographic evidence of a periapical lesion?
    (a) Sodium hypochlorite (d) Sterile water
    (b) Chlorhexidine (e) Other
    (c) Saline
12. Which of the following irrigants would you primarily utilize when treating a previously treated tooth?
    (a) Sodium hypochlorite (d) Sterile water
    (b) Chlorhexidine (e) Other
    (c) Saline (f) Do not perform retreatment
13. Which, if any, adjuncts to irrigation do you utilize? (Please select all that apply)?
    (a) Ultrasonic activation (d) Negative pressure (example: EndoVac)
    (b) Sonic activation (e) Other
    (c) Subsonic activation (f) No adjuncts used
    (Example: EndoActivator)
14. What is the routine gauge of the needle employed by you during syringe irrigation?
    (a) 26 gauge (c) 30 gauge
    (b) 27 gauge (d) 31 gauge
15. In your opinion, which irrigant do you feel effective?
    (a) Sodium hypochlorite (e) EDTA
    (b) Chlorhexidine (f) MTAD
    (c) Saline (g) Citric acid
    (d) Sterile water (h) Other
    (EDTA: Ethylene diaminetetraacetic acid)
16. How much depth of penetration of needle do you prefer for irrigation?
    1. 1 mm from apical foramen 3. 3 mm from apical foramen
    2. 2 mm from apical foramen 4. 4 mm from apical foramen
17. Which tip design of the needle do you use?
    1. Brush covered needle (Navitip FX) 3. Single-beveled needle
    2. Side-vented needle (RC twents) 4. Other
18. What is the duration of irrigation do you prefer per canal?
    1. <30 seconds 3. 1–2 minutes
    2. 30 seconds–1 minute 4. >2 minutes
19. What is the volume of syringe do you use for irrigation?
    1. 1 mL 3. 5 mL
    2. 2.5 mL 4. 10 mL
20. Do you feel this survey helps in improving outcome of endodontic treatment?
    1. Yes
    2. No

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Table 2: List of surveys

Study year	*Location*	*No. of dentists surveyed*	*Information gathered in the survey*
Whitworth et al (2000)[9]	United Kingdom	643, by post	(a) Choice of irrigant (b) Use of rubber dam
Moss et al (2001)[10]	United States	250, web-based	(a) Removal of smear layer prior to obturation
Slaus and Bottenberg (2002)[11]	Belgium	4545, web-based	(a) choice of irrigants and disinfectants
Clarkson et al (2003)[12]	Australia	200, by telephone	(a) Use of NaOCl
Al-Omari (2004)[13]	North Jordan	181, by post	(a) Methods of isolation (b) Choice of irrigant (c) Concentration of irrigant
Dutner et al (2012)[14]	United States	3844, web-based	(a) Irrigant selection (b) Irrigant concentration (c) Smear layer removal (d) Adjuncts used (e) Choice of irrigant used for different clinical situations

(Contd…)

(Contd…)

Study year	Location	No. of dentists surveyed	Information gathered in the survey
Gopikrishna et al (2013)[1]	India	794, by post	(a) Irrigant selection (b) Irrigant concentration (c) Smear layer removal (d) Adjuncts used (e) Choice of irrigant used for different clinical situations (f) Routine gauge of the needle employed
Shrestha et al (2013)[15]	Kathmandu, India	120, by hand	(a) Irrigant selection
Hussain and Khan (2014)[16]	Pakistan	269, by hand	(a) Choice of irrigant used for different clinical situations (b) Concentration and volume of irrigant used (c) Adjuncts to irrigation
Damanpreet et al (2014)[17]	Himachal Pradesh, India	544, web-based	(a) Irrigant selection (b) Irrigant concentration (c) Smear layer removal (d) Adjuncts used
de Gregorio et al (2015)[18]	Spain	238, web-based	(a) Irrigant selection (b) Irrigant concentration (c) Smear layer removal (d) Adjuncts used (e) Enlargement of the apical preparation (f) Maintenance of apical patency
Tosić et al (2016)[19]	Serbia	1,184, web-based	(a) Irrigant selection (b) Irrigant concentration
Present survey	Nellore, India	144, by hand	(a) Irrigant selection (b) Irrigant concentration (c) Smear layer removal (d) Adjuncts used (e) Choice of irrigant used for different clinical situations (f) Gauge of needle used (g) Tip design of needle (h) Depth of needle penetration (i) Volume of the syringe used (j) Volume of irrigant used (k) Duration of irrigation

The questions were so framed to cover all the information regarding irrigation, ranging from irrigant selection, irrigant concentration, smear layer removal, adjuncts to irrigation, gauge of needle, tip design of needle, depth of needle penetration, volume of syringe, volume of irrigant used, duration of irrigation, choice of irrigant in vital, non-vital, and retreatment cases. Questions consisted of numeric rankings, multiple choices, and multiple selections with options for write-in answers where appropriate.

The data were compiled by a single assessor and analyzed using the statistical software IBM Statistical Package for the Social Sciences (SPSS) version 21.

RESULTS

There were 144 respondents out of 150, obtaining a response rate of 96%. Table 3 displays the results for each question of the survey. Majority of them are having 5 to 10 years of experience in endodontic therapy (Table 4).

When asked for all the irrigants using irrespective of condition of the case it revealed that 100% of respondents are using saline. Along with saline 77.7% are using NaOCl, 55.55 are using EDTA, 27.7% are using chlorhexidine, 11.1% are using hydrogen peroxide, 6.94% are using sterile water, and none of them are using mixture of doxycycline, citric acid, and Tween 80 detergent (MTAD) and citric acid (Graph 1).

Our results revealed that majority of respondents, 47.2%, were using saline as primary or chief irrigant and 44.4% of respondents were using NaOCl as their primary irrigant (Graph 2).

When asked to rank the reasons for their primary irrigant selection antibacterial capability was most

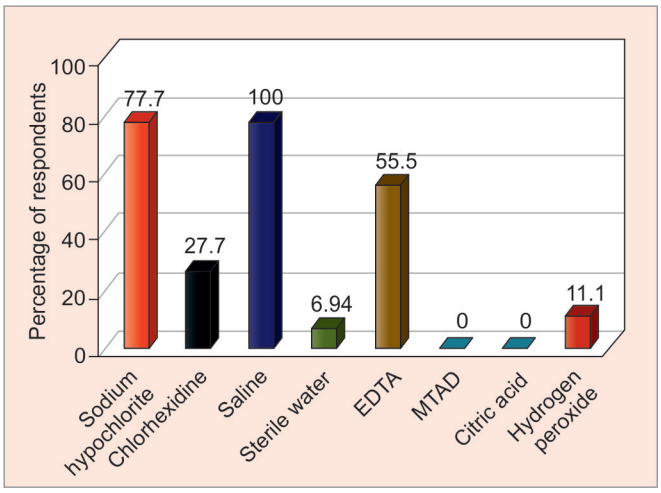
Table 3: Results of the present survey

Results of the survey		
		Result
Topic	*Category*	*Dentist No. (%)*
Irrigants utilized	Sodium hypochlorite	112 (77.7)
	EDTA	80 (55.5)
	Chlorhexidine	40 (27.7)
	Saline	144 (100)
	MTAD	0
	Citric acid	0
	Sterile water	10 (6.94)
	Other	16 (11.1)
Primary irrigant	Sodium hypochlorite	64 (44.4)
	Chlorhexidine	4 (2.8)
	Saline	68 (47.2)
	EDTA	8 (5.6)
	others	0
Sodium hypochlorite concentration	<0.5%	8 (5.6)
	0.5–1.5%	18 (12.5)
	1.6–2.5%	8 (5.6)
	2.6–4.0%	74 (51.4)
	4.1–5.0%	0
	>5.0%	4 (2.8)
	I do not use NaOCl	32 (22.2)
Chlorhexidine concentration	0.2%	22 (15.3)
	0.18–1.9%	2 (1.4)
	2.0%	80 (55.6)
	>2.0%	0
	I do not use Chlorhexidine	40 (27.8)
Adjunct to irrigation	Ultrasonic activation	8 (5.6)
	Subsonic activation (Endoactivator)	1 (0.7)
	Negative pressure	0
	Laser	8 (5.6)
	No adjuncts used	127 (88.1)
Routine gauge of the needle used	26 gauge	128 (88.9)
	27 gauge	12 (8.3)
	30 gauge	4 (2.8)
	31 gauge	0
Tip design of the needle used	Brush covered needle (Navitip FX)	0
	Side-vented needle (RC twents)	4 (2.8)
	Single-beveled needle	140 (97.2)
	Other	0
Depth of penetration of needle from apical foramen	1 mm	16 (11.1)
	2 mm	72 (50)
	3 mm	50 (34.7)
	4 mm	6 (4.2)
Volume of syringe preferred	1 mL	0
	2.5 mL	40 (27.8)
	5 mL	84 (58.3)
	10 mL	20 (13.9)
Volume of irrigant used per canal	0.5 mL	0
	2.5 mL	36 (25)
	5–10 mL	80 (55.6)
	>10 mL	28 (19.4)
Duration of irrigation	<30 seconds	32 (22.2)
	30 seconds–1 minute	96 (66.7)
	1–2 minutes	16 (11.1)
	>2 minutes	0

EDTA: Ethylene diaminetetraacetic acid; MTAD: Mixture of doxycycline, citric acid, and Tween 80 detergent

Table 4: Number of respondents and their experience in endodontic therapy

Years of practice of endodontic therapy	*Dentist no.*
>30	6 (4.2)
21–30	8 (5.6)
11–20	22 (15.3)
5–10	58 (40.3)
<5	48 (33.3)
Still in training	2 (1.4)



Graph 1: Irrigants utilized. Ethylene diaminetetraacetic acid (EDTA). Mixture of Doxycycline (MTAD), Citric acid, and Tween 80 detergent

important (61.1%), followed in order by tissue dissolution (19.4%), biocompatibility (11.1%), substantivity (5.6%), and expense (2.8%).

Most of the practitioners were using NaOCl in concentration of 2.6 to 4%; 59.7% of respondents aim to remove the smear layer during endodontic treatment. A total of 66.7% of the participants claim to alter their irrigant selection based on the pulpal or periapical diagnosis.

A very less percentage of respondents (11.9%) use an adjunct to irrigation, with 5.6% using ultrasonic activation, 5.6% using laser, and 0.7% using subsonic activation (Endoactivator). None of the practitioners were found using negative pressure irrigation with systems, such as EndoVac (Graph 3).

When asked for choice of primary irrigant in three different conditions like vital pulp, radiographic evidence of periapical lesion, and retreatment, 51.4% were reported using saline in treating vital pulp, 45.8 and 38.9% were using NaOCl in cases of radiographic evidence of periapical lesion and retreatment respectively. A total of 11.1% of the participants do not perform retreatment.

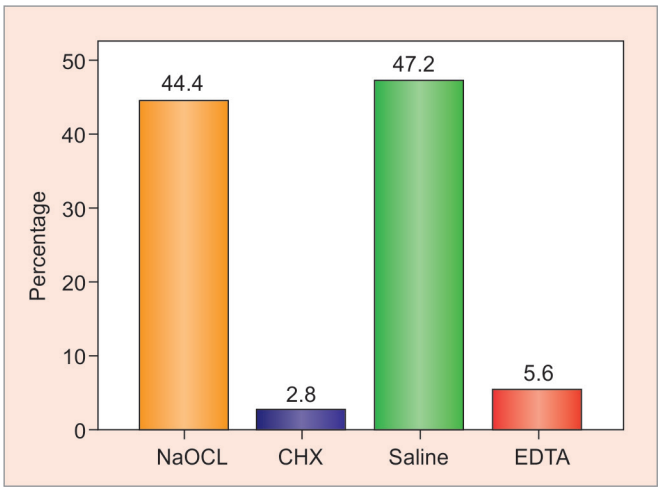
Majority of respondents (88.9%) were using 26 gauge needle for syringe irrigation with single-beveled tip design (97.2%). Very few respondents (2.8%) were using side-vented needle for irrigation.

Majority of respondents were using the 5 mL syringe for irrigation at a depth of 2 mm from apical foramen, employing 5 to 10 mL of irrigant for 30 seconds to 1 minute per canal.

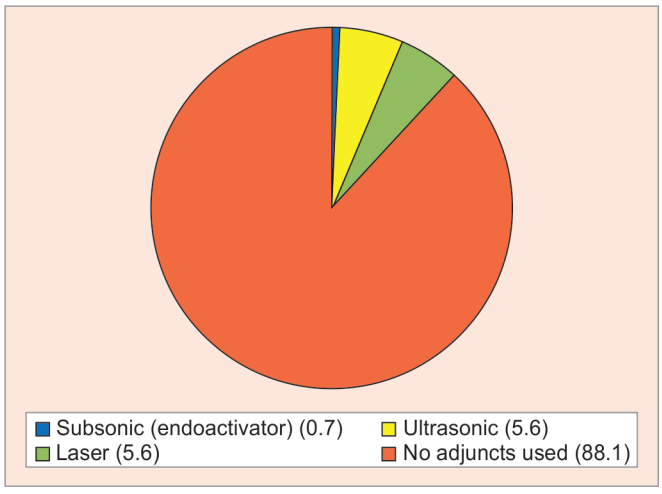
DISCUSSION

This survey aimed to collect data from GDPs in Nellore urban area, Andhra Pradesh, India. In the present study it was found that the majority of respondents (47.2%) use normal saline as their primary irrigant at a concentration of 0.9%, which is similar to the findings of the survey in Pakistan reported by Hussain and Khan[16] (Table 5).

When assessing the primary irrigant of choice, majority of the other researchers had NaOCl as their primary irrigant, except for Jenkins et al[20] who reported the use of local anesthetic as a primary irrigant and Ahmed et al[21]



Graph 2: Percentage of respondents who utilize each irrigant as their primary or main irrigant during root canal treatment. NaOCl – sodium hypochlorite; CHX – chlorhexidine; EDTA – ethylene diaminetetraacetic acid



Graph 3: Percentage of respondents using adjuncts to irrigation

Table 5: Comparison of previous survey results with present survey

	Studies reporting irrigation protocol			
Survey questions	*Whitworth et al (2000)*[9]	*Moss et al (2001)*[10]	*Slaus and Bottenberg (2002)*[11]	*Clarkson et al (2003)*[12]
Primary irrigant selection	Local anesthetic solution (63)	–	NaOCl (59.2)	NaOCl (94)
Concentration of NaOCl used	–	–	2 (27.7)	1
Smear layer removal	–	51% remove smear layer	–	–
Adjuncts used during irrigation	–	–	–	–
	Studies reporting irrigation protocol			
Survey questions	*Al-Omari (2004)*[13]	*Dutner et al (2012)*[14]	*Gopikrishna et al (2013)*[1]	*Shrestha et al (2013)*[15]
Primary irrigant selection	H_2O_2(33.6)	NaOCl (91.0)	NaOCl (92.8)	NaOCl (91.81) Saline (91.81)
Concentration of NaOCl used	0.5	>5	2.6–4	–
Smear layer removal	–	77% remove smear layer	68% remove	–
Adjuncts used during irrigation	–	Ultrasonic (48)	Ultrasonic (48)	–
	Studies reporting irrigation protocol			
Survey questions	*Hussain et al (2014)*[16]	*Damanpreet et al (2014)*[17]	*de Gregorio et al (2015)*[18]	*Tosić et al (2016)*[19]
Primary irrigant selection	NaOCl in case of vital pulp, nonvital pulp and immature apices Normal saline in case of periapical radiolucency	NaOCl (38)	NaOCl (93.3 of GDP's, 98.3% of endodontists)	H_2O_2
Concentration of NaOCl used	2.5 (28.9)	>5	<2.5 (GDP's) >2.5 (Endodontists)	>5
Smear layer removal	–	21% remove	73.1% remove (GDP's) 95% remove (Endodontists)	–
Adjuncts used	–	Ultrasonic (5) Sonic (2)	–	
Survey questions	*Present survey*			
Primary irrigant selection	Normal saline at 0.9% concentration			
Concentration of NaOCl used	2.6–4.0% (51.4)			
Smear layer removal	59.7% remove			
Adjuncts used during irrigation	Ultrasonic (5.6) Subsonic (0.7) Laser (5.6)			

NaOCl: Sodium hypochlorite; H_2O_2: Hydrogen peroxide; GDP's: General dental practitioners

who reported the use of hydrogen peroxide. Although there was a variety of other irrigants being used in international studies, but none of them reported the use of normal saline as observed in the present study. The probable reason for such a finding could be the ease of availability of normal saline, its cost effectiveness as opposed to other effective irrigants and the established fact that normal saline is least harmful to the oral hard and soft tissues.

The results were, however, not comparable to a survey conducted by Dutner et al[14] among endodontists of American association and Gopikrishna et al[1] among endodontic postgraduates in Indian institutions where NaOCl was used as primary irrigant for its high tissue dissolving capacity and antibacterial property (Table 5).

At the same time, the use of chief irrigants with good substantivity like chlorhexidine was found to be low among the respondents. The earlier studies by Torabinejad recommend the use of chlorhexidine as root canal irrigant, especially in the cases of retreatment and failures, which have increased over the past.[22,23]

Although 59.7% of the respondents in the study aimed to remove smear layer, 47.2% use saline as primary irrigant; thus showing that majority of dental practitioners in the city were not routinely using irrigants like EDTA and citric acid which are effective in removing smear layer.

Even though only 44.4% use NaOCl as primary irrigant, 61.1% of participants claim that they would select primary irrigant based on antibacterial capability. These results were showing that some of the respondents are having deficit in knowledge on properties of irrigant and smear layer removal. So there is a high need to get aware-

ness on properties and action of irrigants and updating their knowledge and its clinical application in this aspect for successful endodontic treatment.

Although 66.7% of the participants claim to change the irrigant according to periapical diagnosis, 47.2% use saline as primary irrigant. Very few (20.8%) were found preferring irrigants like chlorhexidine for teeth with radiographic evidence of periapical lesion and previously treated tooth. This finding might be a significant reason behind the failure of root canal treatment experienced by GDPs in their respective practices.

The ideal root canal irrigant has been described by Zehnder[24] as being systemically nontoxic, noncaustic to periodontal tissues, having little potential to cause an anaphylactic reaction, possessing a broad antimicrobial spectrum, capable of dissolving necrotic pulp tissue, inactivating endotoxins, and preventing either the formation of a smear layer or dissolving it once it has formed. Although many kinds of endodontic irrigants have been investigated, none have been able to exhibit all the above-mentioned properties. So using combination of irrigants in specific sequence proposed by Sleiman and Khaled[25] is recommended.

In case of nonvital pulp, initial use of NaOCl that dissolves organic debris should be followed by flushing with saline. In the second step, use of chelating agent like EDTA is recommended, which removes inorganic debris and smear layer; and opening the dentinal tubuli will permit an easy flow of NaOCl or chlorhexidine. For a better disinfection of the endodontic system, it should be followed by flushing with saline. Finally, use of chlorhexidine which has antibacterial property along with substantivity is recommended, especially in case of periapical lesion and endodontic retreatment. Use of chlorhexidine or normal saline as a final rinse is recommended.

In case of vital pulp, initial use of urea peroxide is recommended because of the following advantages. The collagenic antiaggregation effect due to the proteolytic and lipidic affinity of urea peroxide[26] and on addition of NaOCl irrigation will create an effervescent effect between the NaOCl and urea peroxide. This "elevator effect" will evacuate the organic debris outside the access cavity, disorganize the coronal pulp tissue, and help to better detect the canal orifices.[27]

In our study, a very low percentage of only 11.9% respondents were found using any kind of adjunct to irrigation, with no one using negative pressure irrigation systems like Endovac. These results indicate a very high need to introduce such systems at reasonably lower cost to make it affordable for the practitioners.

In the present study most of the respondents preferred 26 gauge needle with single-beveled tip design for syringe irrigation. Different irrigation needle gauges and designs may affect the efficacy of endodontic irrigation in cleaning the root canal. A study by Guerreiro-Tanomaru et al[28] stated that the 30 gauge needles with side and apical opening promoted better apical cleaning at all stages of root canal widening. Kahn et al[29] reported that side-vented closed-end needles were more efficacious than conventional needles in clearing red food dye from root canals.

The results on all the aspects of irrigant usage among the practitioners in the present study indicate a need to update them regarding the use of irrigating solutions for optimum results in endodontic treatment.

CONCLUSION

The findings of this survey are that most of the respondents are using normal saline as primary irrigant with 26 gauge needle being most preferred for syringe irrigation. It shows there is a high need to update the knowledge on effective irrigants than normal saline and at the same time keep a regular check on the methods adopted by the dental practitioners. Further studies covering all the dental practitioners registered under Dental Council of India should be surveyed to regulate and improve the quality of endodontic treatment in dental practice.

REFERENCES

1. Gopikrishna V, Pare S, Pradeep Kumar AR, Narayanan LL. Irrigation protocol among endodontic faculty and post-graduate students in dental colleges of India: a survey. J Conserv Dent 2013 Sep-Oct;16(5):394-398.
2. Peters OA, Schonenberger K, Laib A. Effects of four Ni-Ti preparation techniques on root canal geometry assessed by micro computed tomography. Int Endod J 2001 Apr;34(3): 221-230.
3. Parente JM, Loushine RJ, Susin L, Gu L, Looney SW, Weller RN, Pashley DH, Tay FR. Root canal debridement using manual dynamic agitation or the EndoVac for final irrigation in a closed system and an open system. Int Endod J 2010 Nov;43(11):1001-1012.
4. Hulsmann M, Hahn W. Complications during root canal irrigation: literature review and case reports. Int Endod J 2000 May;33(3):186-193.
5. Carson KR, Goodell GG, McClanahan SB. Comparison of the antimicrobial activity of six irrigants on primary endodontic pathogens. J Endod 2005 Jun;31(6):471-473.
6. Clegg MS, Vertucci FJ, Walker C, Belanger M, Britto LR. The effect of exposure to irrigant solutions on apical dentin biofilms *in vitro*. J Endod 2006 May;32(5):434-437.
7. Garberoglio R, Becce C. Smear layer removal by root canal irrigants. A comparative scanning electron microscopic study. Oral Surg Oral Med Oral Pathol 1994 Sep;78(3):359-367.
8. Gu L, Kim JR, Ling J, Choi KK, Pashley D, Tay F. Review of contemporary irrigant agitation techniques and devices. J Endod 2009 Jun;35(6):791-804.
9. Whitworth JM, Seccombe GV, Shoker K, Steele JG. Use of rubber dam and irrigant selection in UK general dental practice. Int Endod J 2000 Sep;33(5):435-441.

10. Moss HD, Allemang JD, Johnson JD. Philosophies and practices regarding the management of the endodontic smear layer: results from two surveys. J Endod 2001 Aug;27(8):537-539.
11. Slaus G, Bottenberg P. A survey of endodontic practice amongst Flemish dentists. Int Endod J 2002 Sep;35(9):759-767.
12. Clarkson RM, Podlich HM, Savage NW, Moule AJ. A survey of sodium hypochlorite use by general dental practitioners and endodontists in Australia. Aust Dent J 2003 Mar;48(1):20-26.
13. Al-Omari WM. Survey of attitudes, materials and methods employed in endodontic treatment by general dental practitioners in North Jordan. BMC Oral Health 2004 Sep 10;4(1):1.
14. Dutner J, Mines P, Anderson A. Irrigation trends among American association of endodontists members: a web-based survey. J Endod 2012 Jan;38(1):37-40.
15. Shrestha D, Dahal M, Karki S. An endodontic practice profile amongst general dental practitioners in Kathmandu: a questionnaire survey. J Coll Med Sci Nepal 2013;9(4):40-50.
16. Hussain SM, Khan FR. A survey on endodontic irrigants used by dentists in Pakistan. Pak Oral Dent J 2014 Dec;34(4):730-734.
17. Damanpreet, Miglani S, Karda B, Sarangal P. A survey of irrigation practice among dental practitioners in Himachal Pradesh. Dent J Adv Stud 2014;2(2):80-83.
18. de Gregorio C, Arias A, Navarrete N, Cisneros R, Cohenca N. Differences in disinfection protocols for root canal treatments between general dentists and endodontists: a web-based survey. J Am Dent Assoc 2015 Jul;146(7):536-543.
19. Tosić G, Miladinović M, Kovaević M, Stojanović M. Choice of root canal irrigants by Serbian dental practitioners. Vojnosanit Pregl 2016 Jan;73(1):47-52.
20. Jenkins SM, Hayes SJ, Dummer PM. A study of endodontic treatment carried out in dental practice within the UK. Int Endod J 2001 Jan;34(1):16-22.
21. Ahmed MF, Elseed AI, Ibrahim YE. Root canal treatment in general practice in Sudan. Int Endod J 2000 Jul;33(4):316-319.
22. Ohara P, Torabinejad M, Kettering JD. Antibacterial effect of various endodontic irrigants on selected anaerobic bacterias. Endod Dent Traumatol 1993 Jun;9(3):95-100.
23. Erecan E, Ozekinci T, Atakul F, Gul K. Antibacterial activity of 2% chlorhexidine gluconate and 5.25% sodium hypochlorite in infected root canals *in vivo* study. J Endod 2004 Feb;30(2):84-87.
24. Zehnder M. Root canal irrigants. J Endod 2006 May;32(5): 389-398.
25. Sleiman P, Khaled F. Sequence of irrigation in endodontics. Oral Health 2005 May;95:62-65.
26. Buck R, Eleazer P, Staat RH. *In vitro* disinfection of dentinal tubules by various endodontics irrigants. J Endod 1999 Dec;25(12):786-788.
27. Shiozawa A. Characterization of reactive oxygen species generated from the mixture of NaOCI and H_2O_2 used as root canal irrigants. J Endod 2000 Jan;26(1):11-15.
28. Guerreiro-Tanomaru JM, Loiola LE, Morgental RD, Leonardo Rde T, Tanomaru-Filho M. Efficacy of four irrigation needles in cleaning the apical third of root canals. Braz Dent J 2013;24(1):21-24.
29. 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 May;21(5):277-280.