

Recent Trends of Irrigation Practices during Non-surgical Root Canal Treatment among Registered Dental Practitioners in India: A Cross-Sectional Questionnaire-based Survey

Paromita Mazumdar, Shamik Datta

Department of Conservative Dentistry and Endodontics, Guru Nanak Institute of Dental Sciences and Research, Kolkata, West Bengal, India

Abstract

Background: Endodontic treatment success relies on removing microorganisms from the root canal and preventing reinfection. Single-visit endodontic therapy is equally effective as multi-visit therapy, but proper irrigation is crucial. The current cross-sectional survey was conducted to assess the knowledge, attitudes, and practices of dentists across India. **Materials and Methods:** A self-structured questionnaire containing 34 questions was sent to 1000 dentists to conduct this cross-section survey. The survey comprised 4 demographic questions, 15 questions assessing knowledge, 8 questions on attitude, and 7 questions on practices regarding endodontic irrigation. Pearson's Chi-square test was employed to analyze the categorical variables. The alpha level was set at 5%. **Results:** A total of 416 (41.6%) responses were received. Sodium hypochlorite is used as a primary endodontic irrigant used by 320 (42.5%) dental practitioners in India. Syringe irrigation is most commonly performed with a 27-gauge needle. Smear layer removal is widely used with an increased tendency to adjust irrigant protocols based on pulp, periapex, and retreatment status. **Conclusion:** The survey responses were indicative of adequate knowledge among the dentists across India about irrigation; however, continuing dental education programs can enhance the knowledge and make the dentists adept in proper irrigation practices.

Keywords: Activation, Disinfection, Root canal irrigants, Smear layer, Survey.

INTRODUCTION

Eradication of bacteria from the root canal and avoiding reinfection are critical to the effectiveness of endodontic treatment.^[1] With the advent of the rotary armamentarium, a paradigm shift has been observed toward completing the endodontic treatment in a single visit. A Cochrane systematic review found that single-visit endodontic therapy is equally effective as multi-visit endodontic therapy. However, it is crucial to follow the appropriate irrigation strategy.^[2,3] To shape the root canal, continual irrigation is used to remove inflammatory and necrotic tissue, microbes/biofilms, and debris.^[4] Despite advancements in canal shaping procedures and instruments, non-surgical root canal therapy (NSRCT) may leave over 35–40% of the canal surface uninstrumented. Necrotic or viable tissue remnants in the root canal space can sustain surviving bacteria.^[5] Endodontic failures are mostly caused by bacteria that remain in the root canal space after treatment or recolonize the filled canal system. Thereby, irrigation protocols are crucial for disinfecting root canal spaces.^[6]

Irrigation is useful when it penetrates root canals. Syringe and needle irrigation is the most frequent method for delivering irrigants. However, it fails to distribute irrigant 1–2 mm beyond the needle tip.^[7] In addition, the existence of a vapor lock restricts irrigant diffusion in the important apical section of the root canals.^[8,9]

Various irrigant activation techniques have since been developed to curtail the above-mentioned effect such as the manual dynamic activation (MDA), sonic activation systems like Endoactivator, passive ultrasonic irrigation, and negative pressure techniques like Endovac. Recent *in-vitro* studies suggest that mechanical stimulation helps in minimizing

Address for correspondence: Dr. Shamik Datta,
206/9 Cripur Road, P.O: Konnagar, DT: Hooghly - 712 235, Kolkata,
West Bengal, India.
E-mail: shamikdattaendo@gmail.com

Received: Aug. 08, 2024; **Accepted:** Aug. 11, 2024; **Published:** Aug. 17, 2024

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

How to cite this article: Mazumdar P, Datta S. Recent Trends of Irrigation Practices during Non-surgical Root Canal Treatment among Registered Dental Practitioners in India: A Cross-sectional Questionnaire-Based Survey. J Res Adv Dent 2024;15(6):1-8.

Access this article online

Website:
www.jrad.co.in

DOI:
<https://doi.org/10.53064/jrad.2024.15.6.574>

post-operative pain,^[10] besides leading to cleaner canals and isthmi.^[10,11] In view of the above observations, the current survey was conducted to assess the knowledge, attitude, and practice (KAP) of Irrigation Protocol during NSRCT among registered Dental Practitioners in India as studies are sparse in regard of assessing the knowledge, attitude, and practices of Dental Practitioners country-wide.^[1,9,12,13]

MATERIALS AND METHODS

This cross-sectional survey was done from October 2023 to the 1st week of January of the year 2024 at Guru Nanak Institute of Dental Sciences and Research, Panihati, West Bengal. The study was approved by the Institutional Ethics Committee (IEC No: GNIDSR/IEC/22-23/10).

Only registered dental practitioners holding a BDS and/or MDS degree, postgraduate trainee, and/or any additional qualification residing and practicing dentistry in India, giving consent to participate in the study willingly in strict accordance with the Helsinki Declaration were included in the study. Respondents with incomplete responses or who failed to revert within the stipulated period were excluded from the study.

The sample size was calculated using the formula, $S = Z_{1-\alpha/2}^2 \times p(1-p)/d^2$, where $Z_{1-\alpha/2}$ is the standard normal variate (at 5% type 1 error ($P < 0.05$) it is 1.96, P = Expected proportion in population taken as 50% and d is the absolute error or precision (taken as 10% of the expected proportion). The sample size calculation yielded 385 participants to be recruited in the study to achieve adequate power and precision. However, considering the non-response rate, it was decided to circulate the questionnaire to 1000 dentists across the country by email. The database was obtained from the WhatsApp group of specialty organizations.

A questionnaire containing both closed-ended questions and open-ended questions with a total of 35 items based on pre-validated questions from previous research,^[1,9] was constructed to assess the KAP concerning the irrigation protocol. The set of questions was subjected to content validation by an expert panel of five endodontists. Due to a low content validation index (CVI) of the open-ended item, it was dropped from the final questionnaire. The remaining 34 items had a CVI of 1, implying the aptness of the questions to the study objectives. Before commencing the actual study, pilot testing was done among 15 dental students to adjudge the reliability of the questions. A test-retest reliability was done by kappa statistics, resulting in a value of 0.72, indicating substantial reliability. Following this, an electronic version of the questionnaire was configured online using Google Forms (Google Inc., Mountain View, CA, USA), and the generated link was circulated among the target population by email or WhatsApp.

The constructed questionnaire had the following sections tabulated in Tables 1-4

- Section A: 4 questions about General information of the respondent
- Section B: 15 questions to assess the Knowledge of the respondent

Table 1: Distribution of responses of the general information of the survey participants

Q. No.	Questions	n (%)
A. General information		
1	How do you wish to describe your practice?	
	General dentistry	200 (48.08)
	Specialized dentistry	216 (51.92)
2	If it is a specialized practice, what is the specialty you belong to?	
	Conservative dentistry and endodontics	134 (32.21)
	Oral and maxillofacial surgery	10 (2.4)
	Oral medicine and radiology	4 (0.96)
	Orthodontics and dentofacial orthopedics	13 (3.13)
	Pediatric dentistry	25 (6.01)
	Periodontology	1 (0.24)
	Prosthodontics and crown and bridge	21 (5.53)
	Public health dentistry	5 (1.2)
	Oral and maxillofacial pathology and oral microbiology	1 (0.24)
3	For how many years have you been practicing?	
	<5 years	68 (16.3)
	>30 years	78 (18.8)
	11–30 years	128 (30.8)
	5–10 years	11 (2.6)
	Still in training as a postgraduate trainee or pursuing any other certified course	131 (31.5)
4	If you are a trainee, which specialty are you trainee in?	
	Conservative dentistry and endodontics	65 (49.7)
	Oral and maxillofacial surgery	8 (6.1)
	Orthodontics and dentofacial orthopedics	8 (6.1)
	Pediatric dentistry	28 (21.4)
	Prosthodontics and crown and bridge	21 (16.0)
	Periodontology	1 (0.8)

- Section C: 8 questions to assess the Attitude of the respondent
- Section D: 7 questions to assess the Practices of the respondent.

Statistical analysis

The collected data was tabulated in a spreadsheet using Microsoft Excel 2019 and then statistical analysis was carried out using IBM SPSS Statistics for Windows, Version 26.0. (Armonk, NY: IBM Corp). Descriptive statistics were used to report the variables in terms of percentages. The Chi-square test was used to analyze the categorical variables. The $P = 0.05$ was considered as the level of significance.

RESULTS

A total of 416 responses were received with an overall response rate of 41.6%. Among the respondents, 216 (51.92%) respondents were in specialized practice (majorly Endodontics, 134 (62.8%) and the rest practiced general dentistry. 131 (31.5%) respondents were still in training or pursuing a certified course. Among the respondents who were still in training, 65 (49.7%) were specializing in endodontics.

Table 2: Distribution of responses of the survey participants to assess their knowledge concerning endodontic irrigation

Q. No.	Questions with responses	n (%)
11 ^{*M}	If you use hypodermic syringe, then what is the gauge of the needle employed by you during hypodermic syringe irrigation? (Please select all that apply)	
	26 gauge	84 (18.42)
	27 gauge	256 (56.14)
	30 gauge	92 (20.18)
	31 gauge	24 (5.26)
12 ^{*M}	What type of needle is preferred for irrigation? (Please select all that apply)	
	Flat opened end	24 (5.08)
	Beveled end	72 (15.25)
	Closed end with side vent	236 (50)
	Closed end with multiple side vent	140 (29.66)
13 [*]	What is the average depth of insertion of irrigation needle?	
	At the orifice	8 (1.9)
	Just beyond the orifice	38 (9.1)
	In the midroot region	108 (26.0)
	Just short to the apex	88 (21.2)
	To the point binding to the needle to the canal	28 (6.7)
	A few mm coronal to the apical foramen	44 (10.6)
	Cannot specify	102 (24.5)
16 ^{*M}	What is the average volume of irrigant used per canal in each visit by you? (Please select all that apply)	
	0.5 mL	20 (4.54)
	2.5 mL	92 (20.9)
	5–10 mL	192 (43.6)
	>10 mL	84 (19.09)
	Not sure	52 (11.81)
17 [*]	Does your choice of irrigant (s) differ based on the diagnosis on pulpal or periapical condition?	
	Yes	328 (78.8)
	No	70 (16.8)
	Don't Know	18 (4.3)
21 ^{*M}	In your opinion while using sodium hypochlorite (NaOCl) which is the factor that forms the basis for the determination of the concentration of sodium hypochlorite when use as a root canal irrigant? (Please select all that apply)	
	Infective status of the pulp	272 (48.92)
	Pulpal status	208 (37.41)
	Patient anxiety	8 (1.44)
	Patient tolerance	68 (12.23)
22 ^M	In your opinion what should be the concentration of sodium hypochlorite? (please select all that apply)	
	0.50%	24 (4.88)
	1%	24 (4.88)
	2.50%	112 (22.76)
	3%	124 (25.2)
	5.25%	208 (42.28)
23 ^{*M}	In your opinion what should be the concentration of chlorhexidine gluconate? (please select all that apply)	
	0.17%	36 (8.41)
	1%	12 (2.8)
	2.00%	296 (69.16)
	>2.0%	20 (4.67)
	I do not use chlorhexidine gluconate	64 (14.95)

(Contd...)

Table 2: (Continued)

Q. No.	Questions with responses	n (%)
24 ^{*M}	In your opinion what are the most important factors for using root canal irrigant effectively? (Please select all that apply)	
	Composition of the irrigant	168 (14.63)
	Concentration of irrigant	260 (22.65)
	Mechanism of the delivery of the irrigant	220 (19.16)
	None of the above	4 (0.35)
	Temperature of the irrigant	168 (14.63)
	Volume of irrigant	328 (28.57)
25 ^{*M}	In your opinion which are the properties that might affect the nonsurgical endodontic treatment outcome? (please select all that apply)	
	Antibacterial capability	360 (26.35)
	Biocompatibility	184 (13.47)
	Tissue dissolution	272 (19.91)
	Substantivity	160 (11.71)
	Expense	92 (6.73)
	Smear layer removal	294 (21.52)
	Do not know	4 (0.29)
34 ^{*M}	Which of the following forms the basis of decision-making process while choosing irrigation protocol? (Please select all that apply)	
	Current literature	268 (35.26)
	CDE	120 (15.79)
	Peers	104 (13.68)
	Existing knowledge from textbooks	268 (35.26)
29 [*]	Are you aware of the concept of smear layer in endodontics?	
	No	31 (7.5)
	Yes	385 (92.5)
30 [*]	According to you, retaining the smear layer within the root canal system is	
	Beneficial	19 (4.9)
	Detrimental	366 (95.1)
31 [*]	If the above answer is 'detrimental', which of the following agent is the best for removing the smear layer?	
	Chlorohexidine gluconate (CHX)	7 (1.9)
	Citric acid	16 (4.3)
	EDTA	317 (86.6)
	NaOCl	22 (6.0)
	Maleic acid	4 (1.1)
33 [*]	What is the percentage of patients returning with the problem of the same tooth within 2 years of RCT?	
	<5%	259 (62.3)
	5–15%	47 (11.3)
	16–26%	8 (1.9)
	Can't specify	102 (24.5)

^M: Questions with Multi-choice responses, *questions which were statistically significant ($P < 0.001$) on analysis with Chi-square test of proportions

Knowledge-based questions

328 (78.8%) practitioners admitted that their choice of irrigants differed based on the pulpal or periapical diagnosis. 272(48.92%) respondents opined that the infective status of the pulp formed the basis for determining the concentration of sodium hypochlorite (NaOCl). 5.25% of NaOCl was the majorly used concentration ($n = 208, 42.28\%$), while 2% of chlorhexidine (CHX) was majorly employed by the respondents ($n = 296, 69.16\%$). 328 (28.57%) respondents

Table 3: Distribution of responses of the survey participants to assess their Attitude concerning Endodontic irrigation

Q. No.	Questions with Responses	n (%)
5 ^{*M}	In how many appointments do you perform nonsurgical endodontic treatment? (Please select all that apply)	
	Single Visit	28 (6.6)
	Multiple visits	172 (40.57)
	Both	224 (52.83)
6 [*]	If multiple visits are required for nonsurgical endodontic treatment of the tooth, how many times do you ask your patient to visit on an average?	
	2 times	68 (16.3)
	3–4 times	150 (36.1)
	4–6 times	7 (1.7)
	Can not specify	18 (4.3)
	It depends on the condition of the patient and the tooth	173 (41.6)
7 [*]	Do you clean and shape the canal on the same visit that you prepare the access cavity?	
	No	49 (11.8)
	Yes	367 (88.2)
8 [*]	Do you isolate teeth/tooth during non-surgical endodontic treatment of the tooth?	
	Yes	265 (63.7)
	No	47 (11.3)
	Sometimes	104 (25.0)
10 ^{*M}	What is the mode of delivery of irrigation in the canal? (please select all that apply)	
	Hypodermic syringe	333 (56.25)
	NAVI tip	68 (11.49)
	Side vented needle	16 (2.7)
	Sonic irrigation	80 (13.51)
	Ultrasonic irrigation	92 (15.54)
	Other: Endovac	3 (0.51)
26 ^{*M}	How many times do you irrigate the canal during non-surgical endodontic treatment of tooth? (Please select all that apply)	
	Once Finally (After fully shaping and finishing)	4 (0.89)
	Sequentially after every shaping and finishing i.e., after every instrument change	312 (69.64)
	Sequentially after completion of each segment (Apical third/Middle-third/Coronal third)	68 (15.18)
	Multiple times in a random manner	64 (14.29)
27 [*]	Do you aspirate after irrigation?	
	Yes	106 (25.5)
	No	214 (51.4)
	Sometimes	96 (23.1)
28 ^{*M}	Which among the following irrigant activation methods do you use regularly in your dental practice? (Please select all that apply)	
	Manual agitation with Gutta percha	192 (36.36)
	LAI (Laser assisted irrigation)	12 (2.27)
	Sonic (mechanized)	108 (20.45)
	Ultrasonics	120 (22.72)
	The plastic rotary F file	44 (8.33)
	Other	52 (9.84)

^M: Questions with Multi-choice responses, ^{*}questions which were statistically significant (P<0.001) on analysis with Chi-square test of proportions

Table 4: Distribution of responses of the survey participants to assess their Practices concerning Endodontic irrigation

Q No.	Questions with Responses	n (%)
9 ^M	If the answer of the above question is yes then which of the following are employed by you for isolation during nonsurgical endodontic treatment of tooth. (Please select all that apply)	
	Cotton roll	252 (37.06)
	Rubber dam	208 (30.59)
	Suction	220 (32.35)
	Other	0 (0)
14 ^{*M}	Which irrigants do you use either, alone or in combination? (Please select all that apply)	
	Chlorohexidine	248 (18.24)
	Citric acid	8 (0.59)
	EDTA	256 (18.82)
	Hydrogen peroxide	36 (2.64)
	MTAD	12 (0.88)
	Normal saline	344 (25.29)
	Sodium hypochlorite	388 (28.52)
	Sterile water	56 (4.11)
	Any other	12 (0.88)
15 ^{*M}	Which irrigant is used in maximum quantity by you? (please select all that apply)	
	Sodium hypochlorite	320 (42.55)
	Chlorhexidine gluconate	88 (11.7)
	Saline	232 (30.85)
	Sterile water	16 (2.13)
	EDTA	72 (9.57)
	MTAD	8 (1.06)
	Hydrogen peroxide	4 (0.53)
	Betadine	12 (1.6)
18 ^{*M}	If the answer is yes, which of the following irrigants would you use while treating a tooth with a vital pulp? (Please select all that apply)	
	Sodium hypochlorite	304 (51.7)
	Chlorhexidine	36 (6.12)
	Saline	192 (32.65)
	Sterile water	32 (5.44)
	Other	8 (1.36)
	Do not know	16 (2.72)
19 ^{*M}	If the answer is yes, which of the following irrigants would you use while treating a tooth with radiographic evidence of a periapical lesion? (Please select all that apply)	
	Sodium hypochlorite	208 (28.73)
	Chlorhexidine	220 (30.39)
	Saline	228 (31.49)
	Sterile water	32 (4.42)
	Other	16 (2.21)
	Don't know	20 (2.76)
20 ^{*M}	Which of the following irrigants would you use while performing Re-RET? (Please select all that apply)	
	Sodium hypochlorite	304 (33.93)
	Chlorhexidine	248 (27.68)
	Saline	268 (29.91)
	Sterile water	44 (4.91)
	Other	12 (1.34)
	Don't know	20 (2.23)

(Contd...)

Table 4: (Continued)

Q No.	Questions with Responses	n (%)
32*	Which agent do you use to remove the smear layer in your practice?	
	Chlorhexidine	7 (1.8)
	Citric acid	6 (1.8)
	EDTA	329 (87.5)
	Sodium hypochlorite	28 (8.9)

M: Questions with Multi-choice responses, *questions which were statistically significant ($P < 0.001$) on analysis with Chi-square test of proportions

thought that the volume of the irrigant was the most important factor concerning the efficacy of an irrigant. The majority of the respondents were aware of the smear layer in endodontics ($n = 385, 92.5\%$) and considered the same as detrimental ($n = 366, 95.1\%$). Ethylene diamine tetra-acetic acid (EDTA) was the most preferred irrigant to remove the smear layer ($n = 317, 86.6\%$). All the questions belonging to this domain were found to be statistically significant based on the proportion of responses ($P < 0.001$). Knowledge-based questions with their responses have been tabulated in Table 2.

Attitude-based Questions

224 (52.83%) respondents perform the non-surgical endodontic treatment in both single and multiple visits. If a multiple visit is required, 173 (41.6%) respondents opined that the frequency depended on the condition of the tooth. 367 (88.2%) responding dentists performed the chemico-mechanical preparation on the same visit and 265 (63.7%) isolated the teeth undergoing endodontic therapy. A hypodermic syringe was the most preferred mode of irrigant delivery ($n = 333, 56.25\%$). Sequential irrigation after every instrument change was done by 69.64% of the dentists and 214 (51.4%) didn't aspirate the irrigant. Regarding irrigant activation, the majority of the respondents manually activated the irrigant with gutta-percha ($n = 192, 36.36\%$). All the questions belonging to this domain were found to be statistically significant based on the proportion of responses ($P < 0.001$) (Table 3).

Practice-based Questions

Cotton rolls were mostly employed for isolating the teeth ($n = 252, 37.06\%$). 320 (42.55%) respondents preferred using NaOCl, followed by normal saline ($n = 232, 30.85\%$) in the majority of the cases. 304 (51.7%) and 304 (33.93%) respondents used NaOCl as the primary irrigant while treating a vital pulp and during retreatment respectively and 228 (31.49%) used normal saline in a tooth with evidence of a peri-apical lesion. 329 (87.5%) respondents preferred using EDTA for smear layer removal. All the questions belonging to this domain except the question about the mode of isolation were found to be statistically significant based on the proportion of responses ($P < 0.001$) (Table 4).

DISCUSSION

Endodontic treatment requires thorough pulpal debridement and disinfection for long-term success. Endodontic irrigants

effectively remove debris, bacteria, and smear layers from both instrumented and un-instrumented surfaces of complicated root canal systems.^[13]

There are only three earlier surveys conducted among academic endodontists and postgraduate students in India in various dental colleges, which did not involve responses from general dental practitioners (GDPs).^[1,9,12]

Another recent study by Das *et al.*,^[13] evaluated the response of dental clinicians toward irrigation protocols in Endodontics evaluating the correlation between KAP. However, the study was restricted to a regional population. The current KAP survey was thus conducted amongst dental professionals from all over the country. 172 (40.57%) survey respondents preferred completing the endodontic treatment in multiple visits, with 180 (44.55%) of them felt the number of re-calls was dependent on the condition of the patient. The primary reason could be the perception of severe pain or a flare-up following the treatment which prevented the dentists from completing the treatment in a single visit, although the authors do not deny other probable reasons like "wet" canals. Walton and Fouad,^[14] treated 946 individuals and investigated the factors that lead to flare-ups following root canal therapy, and they failed to find any association between patient demographics, systemic diseases, number of appointments, treatment modalities, or antibiotic use.^[15]

Isolation of teeth was practiced by 268 (65.69%) of the dentists where the choice of isolation was nearly equally distributed in using a cotton roll ($n = 252, 37.06\%$), suction ($n = 220, 2.35\%$), and 208 (30.59%) clinicians using a rubber dam. These findings are in contrast to the findings of Suthar *et al.*,^[12] who in their survey among dentists practicing in Gujarat, where 81% responded to using isolation techniques and also in a study by Whitworth *et al.*,^[16] held in United Kingdom where 71% of the dental clinicians were found to be using a rubber dam as a primary isolation method. Only 320 (42.5%) of the practitioners reported the usage of NaOCl as the primary irrigant. Among the rest of the practitioners, 232 (30.85%) use normal saline, 72 (9.57%) EDTA, and 88 (11.7%) use CHX as their primary irrigant. The results are in contrast to the studies by Gopikrishna *et al.*,^[1] Das *et al.*,^[13] and Virdee *et al.*^[17] Figure 1 illustrates the distribution of the survey respondents according to the primary irrigant used. The discrepancies may be attributed to the regional differences in the population of interest. The main reason for using the solution has been ascribed to its excellent anti-bacterial capacity by 360 (26.35%) respondents which has been also observed as the main determinant for deciding on the concentration of the irrigant used. Most of the respondents preferred using NaOCl at a concentration of 5.25% ($n = 208, 42.28\%$). While some earlier investigations^[17,18] showed contradictory results about the comparative effectiveness of NaOCl at different concentrations, newer studies have proven the advantage of high-concentration hypochlorite over 1–2% solutions.^[4,19,20]

Also, in contrast, a survey in Australia found that 80% of endodontists employed a 1% NaOCl solution.^[18] When

enquired about the usage of CHX as an irrigant in their clinic, about 296 (69.16%) of respondents used a 2% concentration of CHX and 64 (14.95%) clinicians denied using the latter as an irrigant. It should be noted that CHX is utilized in dentistry for plaque prevention and disinfection due to its strong antibacterial properties. It has also been widely utilized in endodontics as a final irrigant following EDTA. Although CHX is cytotoxic to human cells, it does not induce discomfort in the same way as NaOCl does if unintentionally extruded into the periapical area. Although CHX is cytotoxic to human cells, it does not induce discomfort in the same way as NaOCl does if unintentionally extruded into the periapical area. CHX does not dissolve organic or inorganic particles, hence it cannot be utilized as the only irrigating solution. CHX destroys microbial cell walls or outer membranes, destroying the organism. However, it kills planktonic bacteria much more slowly than NaOCl; against biofilm bacteria, its effect is equivalent to or lower than 1–2% NaOCl and much weaker than 5 or 6% NaOCl.^[4,19,20] The mode of irrigant delivery by the practitioners was a hypodermic syringe of 27 gauge. Interestingly closed end with multiple side vents was the majorly used needle type with an average insertion depth in the midroot region, followed by just short of the apex or a few millimeters coronal to the apical foramen. Boutsoukis *et al.*,^[21] in his classical computational fluid dynamics model study had reported that a side vented needle should be placed 1 mm from the working length, while a flat-ended needle should be placed 2–3 mm coronal to the working length for proper irrigation, ensuring adequate irrigant replacement in the root canal, besides lowering the risk of any inadvertent irrigant extrusion.

The respondents in the current study were also enquired regarding the choice of irrigants for various pulpal and periapical conditions, to which 304 (75.25%) participants agreed to the notion, and responded that using CHX is cases with periapical lesions and retreatment, in adjunct to NaOCl. The findings are comparable to a study by Gopikrishna *et al.*,^[1] who reported 78% of respondents in their study to alter irrigants based on pulpal or periapical status. Furthermore, as 388 (94.17%) respondents were aware of the concept of smear layer and that it was detrimental in retaining it within the root canal, 320 (84.21%) reported of using EDTA, and 16 (4.21%) used citric acid to remove it, respectively (Figure 2). In 2001, 51% of American endodontists removed the smear layer before root canal obturation,^[22] while 77% did so in 2012.^[23]

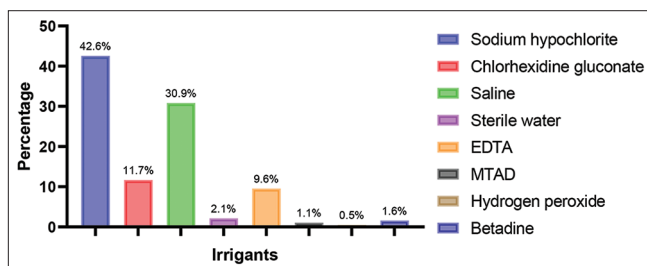


Figure 1: Bar graph showing the distribution of survey respondents according to the primary irrigant used by them

In an Indian survey, 68% of respondents reported removing the smear layer during endodontic procedures.^[1] EDTA is a chelator that is used as the final irrigant following NaOCl. EDTA solution is neutral or slightly alkaline; at acidic pH, EDTA precipitates. EDTA is often used in a 17% or 15% solution, but other investigations have shown that a 5% or even 1% EDTA solution is sufficient for smear layer removal. The recommended time for smear layer removal is approximately 2 min, however, thick coatings may require longer periods of exposure.^[24]

It should be also borne in mind that EDTA only affects the inorganic part of dentine and the smear layer (hydroxyapatite), and total removal of the smear layer requires the use of NaOCl before the final washing with EDTA.^[4,25] EDTA has little or no antibacterial action, while some investigations have shown that it possesses antifungal properties.^[26,27] Yet, EDTA weakens the bacterial cell membrane without killing the cell; yet, it may function synergistically with other compounds, such as CHX, which target the bacterial cell wall more forcefully.^[28] EDTA significantly reduces the effectiveness of NaOCl and should not be used (mixed or alternated) with it. When combined with CHX, EDTA produces a white, hazy precipitate.^[29]

Study participants were also investigated regarding the option of using ultrasonic, sonic, subsonic, or negative pressure as irrigation adjuncts. In our survey, 192 (36.36%) of respondents used MDA, 120 (22.72%) used ultrasonic activation, 108 (20.45%) used sonic or subsonic activation, and the rest used alternative approaches such as plastic F rotary file, laser-assisted irrigation, and other non-specified methods (Figure 3).

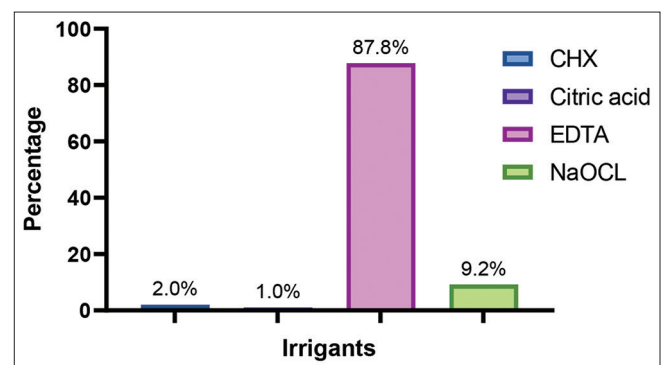


Figure 2: Bar graph showing the distribution of survey respondents according to the irrigant used by them to remove the smear layer

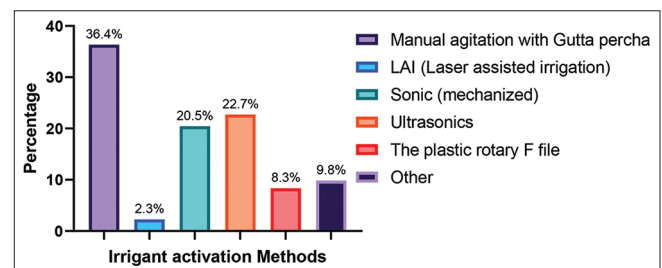


Figure 3: Bar Graph showing the distribution of survey respondents according to the irrigant activation methods used by them

Table 5: Findings of various studies concerning endodontic irrigation practices

S. No.	Author's Name (Year)	Place of Study	Sample size	Objective	Conclusion
1.	Clarkson <i>et al.</i> ^[18]	Australia	200	Investigating the use of NaOCl amongst General dental practitioners (GDPs) and Endodontists of Australia	Approximately 94% of endodontists utilized sodium hypochlorite for irrigation, compared to less than 75% of general dentists. A solution containing a concentration of 1% was utilized by over 90% of general dentists and 80% of endodontists.
2.	Dutner <i>et al.</i> ^[23]	United States of America (USA)	1102	To determine current trends in irrigation selection among endodontists.	Sodium hypochlorite is primarily used by >90% of respondents, and 57% of them use it at a concentration greater than 5%. When receiving endodontic treatment, 77% of respondents want to get rid of the smear layer. In addition to irrigation, at least 45% of respondents said they used an adjuvant.
3.	Suthar <i>et al.</i> ^[12]	Gujarat, India	150	Assessing the variables that affect Gujarat state's endodontists' and general practitioners' choices and applications of irrigants.	According to this study, NS (69%) and 2.5-5% NaOCl (56%) are the most often utilized endodontic irrigants among GDPs, while endodontists employ 2.5-5% NaOCl (69%) and NS (67%). For GDPs and endodontists, the preferred depth of needle insertion into a 3-root canal w4.as somewhat below the apex and a few millimeters coronal to the point where the needle binds to the canal, respectively. Most members of both groups preferred to irrigate with beveled needles and did not use any kind of activation.
4.	Gopikrishna <i>et al.</i> ^[1]	India	794	purpose of this study was to determine the root canal irrigation trends being practiced among the endodontic teaching faculty and post-graduate students in the dental colleges present in India.	The survey results indicate that most educational institutions in India utilize NaOCl (2.6-4.0%) as the primary endodontic irrigant. There is a strong emphasis (68%) on smear layer removal, and a prevalent inclination (78%) to adjust the irrigation protocol based on factors such as pulp condition, periapical status, and during retreatment procedures.
5.	Natanasabapathy <i>et al.</i> ^[9]	India	212	Investigating the utilization of Irrigant Activation Techniques among Endodontists and post-graduate dental students in India.	48.6% of respondents say sodium hypochlorite (NaOCl) is the best option for IAT, followed by chlorhexidine (CHX) at 4.2% and ethylene diamine tetra acetic acid (EDTA) at 2.4%. Irrigant activation was practiced by the majority of responders (87.3%), whereas 4.7% do not utilize it. Ultrasonics was used by 17.2% of Irrigant activating IAT users, while Manual Dynamic Agitation (MDA) was used by 28.7% of users. <10% of responders used EndoVac, which combines sonic and negative pressure.
6.	Virdee <i>et al.</i> ^[17]	United Kingdom (UK) and Ireland	1008	Investigating the most recent endodontic irrigation trends among UK and Ireland's dentistry schools and GDPs.	93.7% of the GDPs used NaOCl and 48.8% used a NaOCl and chelating agent combination as primary irrigant. 39.6% of the respondents used 2-3% concentration of NaOCl with a contact time ranging from 0-10 min (23%). 44.8% used the Manual dynamic irrigation method to activate their irrigants.
7.	Das <i>et al.</i> ^[13]	Kolkata, India	214	Assessing the knowledge, attitude, and practices about endodontic irrigation among GDPs in the Kolkata region.	In addition to employing normal saline and NaOCl and EDTA, the majority of practitioners think about or use irrigation activation in their instances. There is a strong overall tendency to adjust watering schedule based on pulp and periapical state. Since there was a reasonable linear correlation found between the knowledge, attitude, and practice scores, it is reasonable to anticipate that everyday clinical practice will continue to improve in the future.
8.	Present Study	India	416	The current cross-sectional survey was conducted to assess the knowledge, attitudes, and practices of dentists across India.	NaOCl is used as a primary endodontic irrigant used by the 42.5% of dental practitioners in India. Syringe irrigation is most commonly performed with a 27-gauge needle. Smear layer removal is widely used with an increased tendency to adjust irrigant protocols based on pulp, periapex, and retreatment status. 192 (36.36%) of respondents used MDA, 120 (22.72%) used ultrasonic activation, 108 (20.45%) used sonic or subsonic activation

NaOCl: Sodium hypochlorite, EDTA: Ethylene diamine tetra-acetic acid, NS: Normal Saline, GDPs: General dental practitioners

A survey in the United Kingdom and Ireland^[17] claimed 44.8% of the GDPs using MDA, while 40.2% refrained from using any irrigant activation technique. Endodontists in the American Survey used ultrasonic adjuncts at a rate of 48%,^[24] while in the Indian survey, 47% used ultrasonic activation of the irrigating solutions.^[1] Table 5 summarizes the findings of various National and International research pertaining to irrigation practices.

Limitations

The potential limitations of the survey can be attributed to the inherent nature of a survey, which translates to socially desirable responses from the respondents, leading to the reception of alternate notions. Furthermore, due to the lack of time and non-responsiveness, authors cannot disregard the issue of equal representation of dentists from every region of the country.

Future research should be carried out to assess the practices of the GDPs across countries, which will further enable the formulation of hypotheses for upcoming clinical trials and help comprehend the various irrigation practices around the globe.

CONCLUSION

The current survey found that NaOCl is the predominant endodontic irrigant used by the majority of dental practitioners in India. Syringe irrigation is most commonly performed with a 27-gauge needle. Smear layer removal is widely used with an increased tendency to adjust irrigant protocols based on pulp, periapex, and retreatment status. The survey also indicates that knowledge behind their decisions was primarily from textbooks.

REFERENCES

- Gopikrishna V, Pare S, Pradeep Kumar A, Lakshmi Narayanan L. Irrigation protocol among endodontic faculty and post-graduate students in dental colleges of India: A survey. *J Conserv Dent* 2013;16:394-8.
- Coelho BS, Do Amaral RO, Leonardi DP, Marques-da-Silva B, Silva-Sousa YT, De Carvalho FM, *et al.* Performance of three single instrument systems in the preparation of long oval canals. *Braz Dent J* 2016;27:217-22.
- Srinivasan S, Kadandale S, Ramachandran A, Vijayakumar N, Karunakaran J, Rajkumar J. Irrigation protocols-knowledge, attitude and practice among dental professionals in India: A web-based survey. *J Res Med Dent Sci* 2022;10:79-85.
- Haapasalo M, Qian W, Shen Y. Irrigation: Beyond the smear layer. *Endod Top* 2012;27:35-53.
- Love RM. *Enterococcus faecalis*--a mechanism for its role in endodontic failure. *Int Endod J* 2001;34:399-405.
- Iqbal A. Antimicrobial irrigants in the endodontic therapy. *Int J Health Sci (Qassim)* 2012;6:186-92.
- 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.
- Tay FR, Gu LS, Schoeffel GJ, Wimmer C, Susin L, Zhang K, *et al.* Effect of vapor lock on root canal debridement by using a side-vented needle for positive-pressure irrigant delivery. *J Endod* 2010;36:745-50.
- Natanasabapathy V, Durvasulu A, Krithikadatta J, Namasivayam A, Deivanayagam K, Manali S, *et al.* Current trends in the use of irrigant activation techniques among endodontists and post-graduate dental students in India-a knowledge, attitude and practice based survey. *Eur Endod J* 2020;5:73-80.
- Susila A, Minu J. Activated irrigation vs. conventional non-activated irrigation in endodontics-a systematic review. *Eur Endod J* 2019;4:96-110.
- Nagendrababu V, Jayaraman J, Suresh A, Kalyanasundaram S, Neelakantan P. Effectiveness of ultrasonically activated irrigation on root canal disinfection: A systematic review of *in vitro* studies. *Clin Oral Investig* 2018;22:655-70.
- Suthar S, Shah V, Chokshi P, Sanghvi Z, Chokshi S, Vaidya R. Current trends in endodontic irrigation amongst general practitioners and endodontists in Gujarat. *J Ahmedabad Dent Coll Hosp* 2012;3:75.
- Das S, Majumder G, Nath Tudu S, Bhattacharya S. Recent praxis in endodontic irrigation: A region-based cross-sectional survey assessing the knowledge, attitude, and practices among general dental practitioners. *J West Bengal Univ Health Sci* 2022;3:40-50.
- Walton R, Fouad A. Endodontic interappointment flare-ups: A prospective study of incidence and related factors. *J Endod* 1992;18:172-7.
- Inamoto K, Kojima K, Nagamatsu K, Hamaguchi A, Nakata K, Nakamura H. A survey of the incidence of single-visit endodontics. *J Endod* 2002;28:371-4.
- Whitworth JM, Seccombe GV, Shoker K, Steele JG. Use of rubber dam and irrigant selection in UK general dental practice. *Int Endod J* 2000;33:435-41.
- Virdee SS, Ravaghi V, Camilleri J, Cooper P, Tomson P. Current trends in endodontic irrigation amongst general dental practitioners and dental schools within the United Kingdom and Ireland: A cross-sectional survey. *Br Dent J* 2020;1-7.
- 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;48:20-6.
- Ma J, Wang Z, Shen Y, Haapasalo M. A new noninvasive model to study the effectiveness of dentin disinfection by using confocal laser scanning microscopy. *J Endod* 2011;37:1380-5.
- Wang Z, Shen Y, Haapasalo M. Effectiveness of endodontic disinfecting solutions against young and old *Enterococcus faecalis* biofilms in dentin canals. *J Endod* 2012;38:1376-9.
- Boutsoukakis C, Gogos C, Verhaagen B, Versluis M, Kastrinakis E, Van der Sluis LW. 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.
- Moss HD, Allemang JD, Johnson JD. Philosophies and practices regarding the management of the endodontic smear layer: Results from two surveys. *J Endod* 2001;27:537-9.
- Dutner J, Mines P, Anderson A. Irrigation trends among American association of endodontists members: A web-based survey. *J Endod* 2012;38:37-40.
- Haapasalo M, Shen Y, Qian W, Gao Y. Irrigation in endodontics. *Dent Clin North Am* 2010;54:291-312.
- Goldman M, Goldman LB, Cavaleri R, Bogis J, Lin PS. The efficacy of several endodontic irrigating solutions: A scanning electron microscopic study: Part 2. *J Endod* 1982;8:487-92.
- Sen BH, Akdeniz BG, Denizci AA. The effect of ethylenediamine-tetraacetic acid on *Candida albicans*. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2000;90:651-5.
- Ates M, Akdeniz BG, Sen BH. The effect of calcium chelating or binding agents on *Candida albicans*. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2005;100:626-30.
- Stojicic S, Shen Y, Qian W, Johnson B, Haapasalo M. Antibacterial and smear layer removal ability of a novel irrigant, QMiX. *Int Endod J* 2012;45:363-71.
- Zehnder M, Schmidlin P, Sener B, Waltimo T. Chelation in root canal therapy reconsidered. *J Endod* 2005;31:817-20.