MJoSHT
Malaysian Journal of Science, Health & Technology
[mjosht.usim.edu.my]
USIM Penerbit USIM PRESS

Article

Survey on the Pattern of Practice in Using Sodium Hypochlorite as Root Canal Irrigant

Sobrina Mohamed Khazin[1], Hanin Hemdi[2], Khairina Amyra Khirul Ambia[3], Noorhazayti Ab. Halim[4] and Diyana Kamarudin[5]

[1] Department of Restorative Dentistry, Kulliyyah of Dentistry, International Islamic University Malaysia, Bandar Indera Mahkota, 25200, Kuantan, Pahang, Malaysia.

[2] Klinik Pergigian Bandar Pekan, 26600 Pekan, Pahang, Malaysia.

[3] Klinik Pergigian Seri Kembangan, Taman Muhibbah, Seri Kembangan, 43300, Selangor, Malaysia.

[4] Department of Paediatric Dentistry and Dental Public Health, Kulliyyah of Dentistry, International Islamic University Malaysia, Bandar Indera Mahkota, 25200, Kuantan, Pahang, Malaysia.

[5] Faculty of Contemporary International Studies, IPU New Zealand, 4410 Palmerston North, New Zealand.

Correspondence should be addressed to:
Sobrina Mohamed Khazin; sobrina@iium.edu.my

Article Info
Article history:
Received:16 March 2025
Accepted: 17 September 2025
Published: 15 October 2025

Academic Editor:
Normaliza Ab Malik

Malaysian Journal of Science, Health & Technology

MJoSHT2025, Volume 11, Issue No. 2
eISSN: 2601-0003

https://doi.org/10.33102/mjosht.446

Abstract*— Sodium hypochlorite (NaOCl) is the most used endodontic irrigant due to its antimicrobial and organic tissue-dissolving properties. However, NaOCl solutions are unstable; exposure to light, heat, air, metals, and organic substances can reduce the available chlorine concentration with concomitant loss of antimicrobial and tissue-dissolving properties. NaOCl delivery mode during endodontic treatment plays a role in its efficacy in reaching the intricate anatomy of the root canal system. This study sought to investigate the practice patterns of Malaysian dental practitioners concerning the type, storage, dilution, and delivery of NaOCl in their clinical settings. A cross-sectional study was conducted among Malaysian dental practitioners via the online platform. Ninety-seven respondents were recruited, which comprised 88.7% of general dental practitioners and 11.3% of dental specialists. The most common type of NaOCl used is domestic bleach, with the majority using concentrations of 3.5%–6%. Most dental practitioners store domestic bleach in a cupboard and use it diluted. If it is diluted, a majority of the NaOCl is diluted every time before each treatment. The closed-ended side-vented needle is the most common needle used for endodontic irrigation, and it is 30G in size. Manual activation is used to irrigate the canal. The majority of dental practitioners practise proper NaOCl handling to preserve its antimicrobial properties.

***Keywords*— domestic bleach; endodontic irrigant; hypochlorite accident; Malaysia.**

I. INTRODUCTION

Sodium hypochlorite (NaOCl) is the most used endodontic irrigant for non-surgical root canal treatment (NSRCT) due to its antimicrobial and tissue-dissolving properties. Free available chlorine (FAC) is the active component of NaOCl that is responsible for its therapeutic effect [1]. However, NaOCl can be cytotoxic when in contact with periapical tissues [2] and can cause hypochlorite accidents.

It has been suggested that NaOCl cytotoxicity be reduced through dilution, but this may affect its antimicrobial and tissue-dissolving capacity [3]. Furthermore, the delivery method may also play a role in reducing the possibility of NaOCl accidents [4].

FAC content in NaOCl may be affected by several factors such as (i) concentration, (ii) exposure to light, air, metals, and organic substances, (iii) surface tension, (iv) temperature [2], and (v) method of delivery [5].

Despite this, the literature on the practices of NaOCl handling for endodontic treatment among Malaysian dental practitioners is limited. It is imperative to investigate how dental practitioners handle NaOCl to get the best and safe outcome from NaOCl use in endodontics. Hence, this study aimed to determine the type, pattern of use, and mode of delivery of NaOCl among Malaysian dental practitioners.

II. MATERIAL AND METHOD

Prior to study commencement, ethical approval was obtained from the International Islamic University Malaysia (IIUM) Research Ethics Committee (IREC) [Reference no: IREC 2021-023].

A cross-sectional survey was carried out from August to November 2022 involving Malaysian dental practitioners registered with Malaysian Dental Council who use NaOCl as endodontic irrigant routinely during NSRCT. The sample size was calculated using a single proportion formula [6]:

$$n = \left(\frac{z}{\Delta}\right)^2 \times P\,(1-P) \qquad (1)$$

where n is the minimum sample size, Z is the z value corresponding to the confidence level, Δ is the precision value, and P is the expected prevalence. The expected proportion of dental practitioners using NaOCl as root canal irrigant (P) was 58.1% [7]. The z value was set at 1.96 for the level of confidence of 95%, and the desired proportion was 10%. Hence, the minimum sample size required was 94 respondents.

The questionnaire was adapted and modified from a previous study [8]. The modified version consisted of three parts: (i) demographic background, (ii) pattern of NaOCl handling, and (iii) mode of NaOCl delivery. The questions included single and multiple-answer selections and open-ended questions.

The questionnaire was validated for face validity by two dental practitioners, followed by content validity by three endodontists. Consequently, the questionnaire was refined for clarity and scope. Test-retest reliability was conducted on 10 dental practitioners with excellent intra-rater agreement (k = 0.920) with a one-week interval.

The respondents were selected via convenience sampling, whereby the questionnaire was constructed using Google Forms and distributed through online platforms such as WhatsApp, Instagram, and email to Malaysian dental practitioners. A reminder email or message was sent to the respondents who did not reply after three weeks.

Data were analysed using Statistical Package for Social Sciences (SPSS), version 25.0 (IBM Corp., New York, USA). Descriptive analysis was used to describe the demographic background and pattern of NaOCl use. The chi-squared test and Fisher exact test were used to establish an association between the pattern of practice and mode of NaOCl delivery with demographic factors and the association between demographic factors and mode of NaOCl delivery with incidence of NaOCl extrusion. Statistical significance was considered at $p < 0.05$.

III. RESULTS AND DISCUSSION

Ninety-seven respondents were recruited, where 68% (n = 66) were female and 32% (n = 31) were male, with an age range of 25–48 years old (SD: 4.025). The response rate was 100%. The majority of the respondents were general dental practitioners (GDP) (88.7%), had less than five years of post-qualification experience (52.6%), and had treated less than five cases of NSRCT in a month (50.5%). The summary of demographic background is shown in Table 1.

A. The Pattern of NaOCl Handling

1) Type, Storage, and Concentration of NaOCl: The distribution of NaOCl types used is shown in Table 2, with most respondents using domestic bleach (45.4%). The use of domestic bleach is statistically significant for GDP and practitioners with less than 10 years of experience ($p < 0.05$).

The majority of the respondents store NaOCl in the closed cupboard (81.4%). Almost half of the respondents use concentrations of 3.5%–6%. These were significantly observed in practitioners with less than 10 years of post-qualification experience ($p < 0.05$) (Table 2). Only 10.3% of the respondents store NaOCl in a refrigerator, with 40% of them using concentrations of 3.5%–6%. Meanwhile, 8.2% of the respondents were unsure of the concentration used.

Table 1. Demographic Background Of Respondents (N = 97)

Variables		Frequency (%)
Gender	Female	66 (68.0)
	Male	31 (32.0)
Age	21–30 years old	57 (58.8)
	31–40 years old	37 (38.1)
	41–50 years old	3 (3.1)
Specialty qualification	No (general dental practitioner)	87 (88.7)
	Yes (Specialist)	10 (11.3)
Post-qualification experience	<5 years	51 (52.6)
	5–10 years	35 (36.1)
	>10 years	11 (11.3)
NSRCT cases treated in a month	<5 cases	49 (50.5)
	5–10 cases	31 (32.0)
	>10 cases	17 (17.5)

NSRCT: non-surgical root canal treatment.

There are two main sources of NaOCl in dental practice: domestic bleach and specially formulated NaOCl. In this study, the majority of the respondents, especially the GDP, use domestic bleach, which is also similar to other parts of the world [9,10,11]. The widespread use of domestic bleach may be due to its low cost and easy availability from grocery stores. However, concerns exist regarding the FAC concentration of domestic bleach. A previous study by Jungbluth reported no significant difference between domestic bleach and specially formulated NaOCl other than the cost [10]. Other studies have reported that domestic bleach has higher actual FAC concentration than labelled compared to specially formulated NaOCl [12,13].

Although higher FAC concentrations confer better antimicrobial properties, using specially formulated NaOCl is recommended instead of domestic bleach due to the discrepancy between labelled and actual FAC concentrations in domestic bleach [12]. The FAC concentrations in domestic bleach are not recommended in the scientific literature (5.25% and 2.5% w/v) [12]. This incongruity between labelled and actual FAC concentration can have harmful effects, especially if hypochlorite accidents occur. The severity of hypochlorite accidents is concentration-dependent, with more detrimental outcomes seen in higher concentrations. Therefore, caution must be exercised when using undiluted domestic bleach, as its actual concentration may be higher than intended for endodontic use.

Proper NaOCl storage is required to maintain its optimal antimicrobial and tissue-dissolving properties [14]. Whether light exposure influences the FAC concentration of NaOCl has been debated. Some studies have shown that light exposure can potentially deteriorate the FAC concentration of NaOCl [14,15], but a more recent study showed otherwise [16]. This discrepancy may be associated with temperature differences in the research setting. Changes in temperature have been shown to affect NaOCl stability, influencing its FAC concentration [17]. NaOCl stored in the refrigerator has a more stable FAC within 3 months compared to NaOCl stored at room temperature [11]. A study in 2001 [14] compared NaOCl stored in transparent syringes under direct sunlight and in dark and air-conditioned rooms, in which temperature and light were not differentiated. Besides temperature, the solution concentration also plays a role in FAC deterioration. Higher NaOCl concentration showed higher FAC deterioration, while refrigerated low-concentration NaOCl remained stable for up to 200 days [18].

Given these findings, clinicians should be aware of the NaOCl concentration they use and ensure proper storage to maintain its efficacy. A significant portion of the respondents store NaOCl in closed cupboards rather than refrigeration despite using concentrations of 3.5%–6%, highlighting the need for increased awareness regarding best storage practices.

2) Dilution of NaOCl: 56.7% of the respondents dilute their NaOCl, with the majority using distilled water (52.7%) and every time before each treatment (49.1%), but 20% of them were not sure when the solution was diluted (Table 2).

The diluent type and dilution timing of NaOCl can influence the FAC concentration of the solution. Previous studies have shown that diluting NaOCl using tap water increased the rate of FAC deterioration due to contamination of inorganic matter and metal ions from the diluent [12]. Using either distilled water or demineralised water is recommended, where inorganic matter and mineral salts have been filtered out, hence reducing the FAC deterioration in the solution. Although studies investigating the effect of normal saline as a diluent on the FAC concentration in NaOCl is limited, it has been shown that high sodium content in the solution may act as a buffer to counteract FAC deterioration in diluted NaOCl [14]. The effect of high pH from normal saline on NaOCl stability has also not been well studied. Despite the majority of the respondents using distilled water as a diluent in this study, close to half of the respondents use either normal saline or tap water. Both diluents are not a contraindication but should be used cautiously due to their unpredictable effect on the FAC concentration of NaOCl.

The Centers for Disease Control and Prevention (CDC) has recommended that diluted NaOCl be used within 24 hours to maintain its antimicrobial efficacy [19]. Nonetheless, previous studies have shown that diluted NaOCl maintained FAC concentration within the therapeutic level in the duration range between 1 week to 3 months [14,20,21]. The majority of the respondents dilute NaOCl every time before each treatment. This dilution method may seem practical in reducing FAC deterioration of the diluted NaOCl. Still, frequent opening and closing of the concentrated NaOCl bottle can also reduce FAC concentration and consequently reduce the shelf-life of the solution [11]. It was recommended that if NaOCl were to be kept diluted, it should be kept in an airtight and opaque container, away from light and heat, and any residuals should be used within 2 months [14]. Hence, clinicians need to know the diluent type and dilution timing of NaOCl to ensure its efficacy is within the therapeutic range.

B. *Mode of NaOCl Delivery*

1) Type of needle: The majority of the respondents use closed-ended side-vented needles (54.6%) for both GDP and specialists compared to other needle types ($p < 0.05$) (Table 3).

2) Needle size: The majority of the respondents used a needle size of 30G (37.1%), while 11.3% were not sure of the needle size used for irrigation and were all GDP (Table 3).

3) Activated irrigation: The majority of the respondents use activated irrigation (80.4%), and 59% use manual dynamic agitation (MDA) using gutta-percha. This method for activated irrigation is statistically significant among GDP and specialists and practitioners who have less than 10 years of post-qualification experience with less than 10 cases of NSRCT treated in a month ($p < 0.05$). Meanwhile, 5.2% were unsure whether they used activated irrigation and were all GDP with less than 10 years post-qualification experience (Table 3).

There are different irrigation needle types with different sizes available in the market. For endodontic use, it has been shown that open-ended needles increase irrigant flow apically more than closed-ended needles. Open-ended needles can provide good irrigant replacement; however, the high apical pressure may lead to NaOCl extrusion [22,23]. Due to this, the side-vented needle is recommended. To improve irrigant replacement, it should be used within 1 mm short of working length [23]. Although the majority of the respondents in this study use closed-ended side-vented 30G needles, the efficacy of the irrigant flow is still questionable as it also depends on the apical size preparation. It has been shown that when using small needle sizes such as 30G or 31G, apical preparation should be at least size #30 for the irrigant to reach the apical third; especially with size 31G, a higher irrigant flow rate is needed [24]. A larger needle gauge will require even larger apical size preparation to allow the irrigant to flow apically. Previous studies on irrigant flow have mostly been done in vitro, and the majority of the apical sizes used in the studies are more than #30 [22,23,25]. These parameters do not reflect the clinical setting, where the size of apical preparation is dependent on apical gauging. Hence, when using a closed-ended needle, minimally invasive canal preparation can be a concern in terms of debris removal and apical canal disinfection.

The use of activated irrigation can enhance irrigant flow at the apical third despite small apical preparations such as #25 [26]. The majority of the respondents utilise activated irrigation. It appears that the respondents are trying to improve their irrigation method through utilising adjunct treatment modalities. Despite several studies showing ultrasonic and sonic activation are superior in irrigant penetration compared to MDA [26,27], it is the most used method by the respondents and was significant among practitioners with less than 10 years of post-qualification experience and less than 10 NSRCT cases treated in a month. This may be because the gutta-percha or syringes commonly used in MDA are readily available and more affordable. More experienced practitioners with more NSRCT cases may benefit from more costly armamentariums such as sonic, ultrasonic, or negative pressure devices. Despite that, MDA can still be used as an alternative to ultrasonic irrigation [26] and has better irrigant penetration compared to conventional needle irrigation [27]. Furthermore, when using conventional needle irrigation, irrigant flow to the apical may be obstructed by vapour lock due to the closed-system nature of the root canal [28]. Using MDA can cause turbulence of irrigation and diffusion of shear stress that will disrupt the vapour lock [29]. This, however, increases the risk of irrigant extrusion. Hence, using MDA as an adjunct to improve irrigant flow should be used short of working length to reduce the risk of NaOCl extrusion [29].

C. NaOCl Extrusion

Sixteen (16.5%) respondents have experienced NaOCl extrusion at least once in their career. The majority of them use closed-ended side-vented needles (62.5%) with size 30G (43.8%) and use MDA (50%). Nonetheless, these factors are not statistically significant in contributing to the incidence of NaOCl extrusion ($p > 0.05$) (Table 4).

NaOCl extrusion can be attributed to several factors: (i) NaOCl-related, (ii) operator-related, (iii) patient-related, and (iv) tooth-related [4]. The latter two factors are not within the scope of this study. Operator-related factors include the method of NaOCl delivery, such as irrigation technique, type and size of irrigation needle, irrigant flow, and force applied during delivery. Previous studies have shown that conventional needle irrigation causes the most frequent extrusion incidence, followed by sonic and ultrasonic agitation [30] and negative pressure technique [31]. Another study found that MDA causes the highest frequency of extrusion compared to sonic and ultrasonic agitation [25]. Similarly, in this study, MDA was found to cause the highest extrusion incidence compared to other irrigation methods.

Although open-ended and wide-bore needles have been shown to cause a higher frequency of NaOCl extrusion compared to side-vented and smaller gauge needles [4,25], this was not the case in the present study. This discrepancy can be due to sample size disparity, where most respondents use closed-ended and smaller gauge needles. Needle depth, irrigant flow, and force applied during delivery can also contribute to the incidence of extrusion despite using closed-ended, side-vented, and small gauge needles [25]. However, these variables were not considered in the present study.

Operator experience also plays a role in NaOCl extrusion. In this study, although there was no significant difference between post-qualification experience, number of NSRCT performed, and specialty qualification with extrusion incidence (Table 4), higher extrusion percentages were recorded by the respondents with more than five years of post-qualification experience and specialty training. This result may have been attributed to the heterogeneity in the sample size between the groups, where there were limited respondents with more than five years of post-qualification experience and specialty training compared to the other groups. A previous study found that nearly 50% of endodontists in the United States have at least experienced NaOCl extrusion once in their career [32]. Besides that, practitioners with more experience and specialty training may have higher awareness and knowledge in recognising NaOCl extrusion.

D. Limitations and future directions

The major limitation of this study is an uneven distribution of samples across different variables. The significant disparity in sample sizes might have affected the statistical analysis, necessitating a cautious interpretation of the findings. Additionally, as the study relied on self-reported data, there is a potential for response bias, particularly in recalling specific endodontic protocols, such as handling NaOCl before treatment.

Future research is warranted to gain a more comprehensive understanding of the effect of endodontic practice patterns on NaOCl delivery during NSRCT among Malaysian dental practitioners. Future studies should delve deeper into exploring the types of canal preparation methods (apical gauging, taper of canal preparation, or endodontic file types), depth of irrigating needle, the method of irrigant delivery, the contact duration of NaOCl, and heat tempering of NaOCl solution, all of which can affect the antimicrobial and tissue-dissolving properties of NaOCl during endodontic treatment.

Furthermore, incorporating details such as practice location (urban, suburban, or rural), practice setting (private, public, university-affiliated, or military-based institutions), and facility type (primary care clinic or tertiary referral center) is essential. These factors can significantly influence irrigant delivery methods and the use of adjuncts, providing valuable insights into the practices of Malaysian dental practitioners.

To strengthen future research, implementing a cluster sampling method would help achieve a more balanced sample distribution across different variables, ensuring better representation and facilitating more meaningful comparisons among Malaysian dental practitioners.

Further improvement of this study can enhance patient safety by identifying risks and inconsistencies in concentration, irrigation techniques, and accident prevention. It may help standardise clinical protocols, enhance dental education by addressing gaps in training, and uncover barriers to best practices, such as cost concerns or lack of awareness. The findings could also drive innovation in endodontic irrigation and inform regulatory policies for safer and more effective NaOCl usage, ultimately improving clinical outcomes and professional standards in Malaysian dentistry.

Table 2. Association Between Pattern Of Sodium Hypochlorite Handling With Demographic Factors

Variable	Total (%)	Specialty qualification			Post-qualification experience				Number of NSRCT cases in a month			
		No (%)	Yes (%)	*p*-value	<5 years	5–10 years	>10 years	*p*-value	<5 cases	5–10 cases	>10 cases	*p*-value
Type of NaOCl (*n* = 97)												
Domestic bleach	44 (45.4)	43 (49.4)	1 (10.0)	**0.043*** GDP-domestic	27 (52.9)	17 (47.2)	0	**0.006*** domestic - <10 yrs	20 (40.8)	18 (58.1)	6 (35.3)	0.183
Specially formulated	28 (28.9)	23 (26.4)	5 (50.0)		14 (27.5)	10 (27.8)	4 (40.0)		18 (36.7)	5 (16.1)	5 (29.4)	
Both	21 (21.6)	17 (19.5)	4 (40.0)		6 (11.8)	9 (25.0)	6 (60.0)		9 (18.4)	6 (19.4)	6 (35.3)	
Not sure†	4 (4.1)	4 (4.6)	0		4 (7.8)	0	0		2 (4.1)	2 (6.5)	0	
Storage (*n* = 97)												
Closed cupboard	79 (81.4)	71 (81.6)	8 (80.0)	0.971	46 (90.2)	25 (69.4)	8 (80.0)	0.192	41 (83.7)	24 (77.4)	14 (82.4)	0.457
Refrigerator	10 (10.3)	9 (10.3)	1 (10.0)		3 (5.9)	6 (16.7)	1 (10.0)		5 (10.2)	4 (12.9)	1 (5.9)	
Open countertop	7 (7.2)	6 (6.9)	1 (10.0)		1 (2.0)	5 (13.9)	1 (10.0)		3 (6.1)	3 (9.7)	1 (5.9)	
Others	1 (1.0)	1 (1.1)	0		1 (2.0)	0	0		0	0	1 (5.9)	
Concentration (*n* = 97)												
<1%	6 (6.2)	6 (6.9)	0	0.604	2 (3.9)	4 (11.1)	0	**0.041*** 3.5%–6% - <10 yrs	4 (8.2)	2 (6.5)	0	0.163
1%–3%	36 (37.1)	31 (35.6)	5 (50.0)		14 (27.5)	17 (47.2)	5 (50.0)		21 (42.9)	10 (32.3)	5 (29.4)	
3.5%–6%	46 (47.4)	41 (47.1)	5 (50.0)		31 (60.8)	10 (27.8)	5 (50.0)		16 (32.7)	18 (58.1)	12 (70.6)	
Not sure†	9 (9.3)	9 (10.3)	0		4 (7.8)	5 (13.9)	0		8 (16.3)	1 (3.2)	0	
Dilution (*n* = 97)												
Yes	55 (56.7)	49 (56.3)	6 (60.0)	1.000	30 (58.8)	20 (55.6)	5 (50.0)	0.949	32 (65.3)	17 (54.8)	6 (35.3)	0.076
No	41 (42.3)	37 (42.5)	4 (40.0)		21 (41.2)	16 (44.4)	4 (40.0)		16 (32.7)	14 (45.2)	11 (54.7)	
Not sure†	1 (1.1)	1 (1.1)	0		0	0	1 (1.0)		1 (2.0)	0	0	
Type of diluent (*n* = 55)												
Tap water	12 (21.8)	9 (18.4)	3 (50.0)	0.124	5 (16.7)	3 (15.0)	1 (30.0)	**0.025*** distilled water <10 yrs	6 (18.8)	3 (17.6)	3 (50.0)	0.072
Distilled water	29 (52.7)	26 (53.1)	3 (50.0)		17 (56.7)	11 (55.0)	4 (80.0)		14 (43.8)	12 (70.6)	3 (50.0)	
Normal saline	14 (25.5)	14 (28.6)	0		8 (26.7)	6 (30.0)	0		12 (37.5)	2 (11.8)	0	
Time of dilution (*n* = 55)												
Every time before each treatment	27 (49.1)	26 (53.1)	1 (16.7)	0.251	18 (56.3)	6 (40)	3 (50)	0.121	16 (53.3)	11 (55)	0	0.387
Once a day	4 (7.3)	3 (6.1)	1 (16.7)		2 (6.3)	2 (13.3)	0		2 (6.7)	1 (5)	1 (20)	
Before each session	9 (16.4)	7 (14.3)	2 (33.3)		4 (12.5)	2 (13.3)	3 (50)		3 (10)	3 (15)	3 (60)	
Others	4 (7.3)	3 (6.1)	1 (16.7)		2 (6.3)	2 (13.3)	0		1 (3.3)	2 (10)	1 (20)	
Not sure†	11 (20)	10 (20.4)	1 (16.7)		6 (18.8)	5 (33.3)	0		8 (26.7)	3 (15)	0	

GDP; general dental practitioner, MDA; manual dynamic agitation, NSRCT; non-surgical root canal treatment, NaOCl; sodium hypochlorite.

* Chi-squared test showed statistical significance with $p < 0.05$, † excluded from statistical analysis.

Table 3. Association Between Mode Of Delivery Of Sodium Hypochlorite With Demographic Factors

Variable	Total (%)	Specialty qualification			Post-qualification experience				Number of NSRCT cases in a month			
		No (%)	Yes (%)	*p*-value	<5 years	5–10 years	>10 years	*p*-value	<5 cases	5–10 cases	>10 cases	*p*-value
Needle type (*n* = 97)												
Open-ended bevel	18 (18.6)	18 (20.7)	0	**0.020*** Closed-ended side-vented - GDP and specialist	9 (17.6)	3 (25.0)	0	0.138	11 (22.4)	4 (12.9)	3 (17.6)	0.202
Open-ended notch	1 (1.0)	0	1 (10.0)		0	0	1 (10.0)		0	0	1	
Closed-ended side-vented	53 (54.6)	46 (52.9)	7 (70.0)		28 (54.9)	16 (52.8)	6 (60.0)		25 (51.0)	17 (54.8)	11 (64.7)	
Closed-ended double-vented	3 (3.1)	3 (3.4)	0		2 (3.9)	1 (2.8)	0		2 (4.1)	0	1 (5.9)	
Combination	22 (22.7)	20 (23.0)	2 (22.7)		12 (23.5)	7 (19.4)	3 (30.0)		11 (22.4)	10 (32.3)	1 (5.9)	
Needle size (*n* = 97)												
25G	12 (12.4)	12 (13.8)	0	0.155	6 (11.8)	5 (16.7)	0	0.270	9 (18.4)	1 (3.2)	2 (11.8)	0.600
27G	22 (22.7)	17 (19.5)	5 (50.0)		11 (21.6)	6 (16.7)	5 (50.0)		10 (20.4)	8 (25.8)	4 (23.5)	
30G	36 (37.1)	34 (39.1)	2 (20.0)		23 (45.1)	11 (30.6)	2 (20.0)		16 (32.7)	14 (45.2)	6 (35.3)	
Combination	15 (15.5)	12 (13.8)	3 (30.0)		7 (13.7)	5 (13.9)	3 (30.0)		7 (14.3)	4 (12.9)	4 (23.5)	
Others	1 (1.0)	1 (1.1)	0		0	0 (2.8)	0		1 (2.0)	0	0	
Not sure†	11 (11.3)	11 (12.6)	0		4 (7.8)	7 (19.4)	0		6 (12.2)	4 (12.9)	1 (5.9)	
Activated irrigation (*n* = 97)												
No	14 (14.4)	13 (13.4)	1 (1.0)	1.000	11 (21.6)	2 (5.6)	1 (10.0)	0.136	9 (18.4)	3 (9.7)	2 (11.8)	0.443
Yes	78 (80.4)	69 (71.1)	9 (9.3)		39 (76.5)	30 (83.3)	9 (90.0)		36 (73.5)	28 (90.3)	14 (82.4)	
Not sure†	5 (5.2)	5 (5.2)	0		1 (2.0)	4 (11.1)	0		4 (8.2)	0	1 (5.9)	
Activation of irrigation (*n* = 78)												
Manual dynamic agitation	46 (59.0)	45 (65.2)	1 (11.1)	**0.007*** MDA – GDP and specialist	22 (56.4)	23 (76.7)	1 (11.1)	**0.020*** MDA - <10 yrs	24 (66.7)	19 (67.9)	3 (21.4)	**0.004*** MDA - <10 cases
Ultrasonic activation	13 (16.7)	11 (15.9)	2 (22.2)		8 (20.5)	3 (10.0)	2 (22.2)		3 (8.3)	3 (10.7)	7 (50.0)	
Sonic activation	5 (6.4)	3 (4.3)	2 (22.2)		2 (5.1)	1 (3.3)	2 (22.2)		4 (11.1)	0	1 (7.1)	
Combination	14 (17.9)	10 (14.5)	4 (44.4)		7 (17.9)	3 (10.0)	4 (44.4)		5 (13.9)	6 (21.4)	3 (21.4)	

GDP; general dental practitioner, MDA; manual dynamic agitation, NSRCT; non-surgical root canal treatment, NaOCl; sodium hypochlorite.
* Chi-squared test showed statistical significance with $p < 0.05$, † excluded from statistical analysis.

Table 4. Association Between Method Of Sodium Hypochlorite Delivery And Demographic Factors With History Of Sodium Hypochlorite Extrusion (N = 97)

Variable	History of NaOCl extrusion		*p*-value
	Yes (%)	No (%)	
Needle type			
Open-ended bevel	2 (12.5)	16 (19.8)	0.839
Open-ended notch	-	1 (1.2)	
Closed-ended side-vented	10 (62.5)	43 (53.1)	
Closed-ended double-vented	-	3 (3.7)	
Combination of multiple needles	4 (25)	18 (22.2)	
Needle size			
25G	3 (18.8)	9 (11.1)	0.688
27G	3 (18.8)	19 (23.5)	
30G	7 (43.8)	29 (35.8)	
Others	-	1 (1.2)	
Combination of multiple needles	1 (6.3)	14 (17.3)	
Not sure†	2 (12.5)	9 (11.1)	
Activated irrigation			
Not activated	2 (12.5)	12 (14.8)	0.605
Manual dynamic agitation	8 (50)	38 (46.9)	
Ultrasonic activation	2 (12.5)	11 (13.6)	
Sonic activation	2 (12.5)	3 (3.7)	
Combination	2 (12.5)	12 (14.8)	
Not sure†	-	5 (6.2)	
Specialty Qualification			
No	7 (70)	74 (85.1)	0.361
Yes	3 (30)	13 (14.9)	
Post-qualification experience			
<5 years	5 (9.8)	46 (90.2)	0.147
5–10 years	8 (22.2)	28 (77.8)	
>10 years	3 (30.0)	7 (70.0)	
Number of NSRCT cases in a month			
<5 cases	7 (14.3)	42 (85.7)	0.526
5–10 cases	7 (22.6)	24 (77.4)	
>10 cases	2 (11.8)	15 (88.2)	

† Excluded from statistical analysis.

IV. CONCLUSIONS

Within the scope of this study, it can be deduced that most Malaysian dental practitioners who participated in this study relatively practise the proper way of handling and delivering NaOCl to preserve and maximise its antimicrobial properties whilst minimising the possibility of NaOCl extrusion. However, to further enhance treatment effectiveness and prevent complications, it is recommended that standardised guidelines for NaOCl handling be established. These guidelines can be endorsed by regulatory bodies, incorporated into the dental curriculum, and adopted by practitioners.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

ACKNOWLEDGEMENT

The authors would like to thank Assistant Professor Dr. Mohamad Shafiq bin Mohd Ibrahim for his help in statistical analysis.

REFERENCES

[1] U. Krishnan, S. Saji, R. Clarkson, R. Lalloo, and A. J. Moule, "Free active chlorine in sodium hypochlorite solutions admixed with octenidine, smearoff, chlorhexidine, and EDTA," J. Endod., vol. 43, no. 8, pp. 1354-1359, Aug. 2017, doi: 10.1016/j.joen.2017.03.034.

[2] C. Estrela, C. R. A Estrela, E. L. Barbin, J. C. E. Spanó, M. A. Marchesan, and J. D. Pécora, "Mechanism of action of sodium hypochlorite," Braz. Dent. J., vol. 13, no. 2, pp. 113-117, 2002, doi: 10.1590/s0103-64402002000200007.

[3] J. Dutner, P. Mines, and A. Anderson, "Irrigation trends among American Association of Endodontists members: A web-based survey," J. Endod., vol. 38, no. 1, pp. 37-40, Sep. 2021, doi: 10.1016/j.joen.2011.08.013.

[4] A. R. Pai, "Factors influencing the occurrence and progress of sodium hypochlorite accident: A narrative and update review." J. Conserv. Dent., vol. 26, no. 1, pp. 3-11, 2023, doi: 10.4103/jcd.jcd_422_22.

[5] R. Ordinola-Zapata, C. M. Bramante, R. M. Aprecio, R. Handysides, and D. E. Jaramillo, "Biofilm removal by 6% sodium hypochlorite activated by different irrigation techniques," Int. Endod. J., vol. 47, no. 7, pp. 659-666, Jul. 2014, doi: 10.1111/iej.12202.

[6] W. M. A. Wan Ahmad, M. S. Mohd Ibrahim, A. Husein, and M. F. Khamis, Sample size calculations made easy using G*Power, Pulau Pinang, Malaysia: Penerbit USM, 2018.

[7] M. S. AL-Zahrani and A. G. AL-Zahrani, "Sodium hypochlorite accident in endodontics: An update review," Int. J. Dent. Oral Health, vol. 2, no. 2, pp. 1-4, 2016, doi: 10.16966/2378-7090.168.

[8] S. O. Basudan, "Sodium hypochlorite use, storage, and delivery methods: A survey," Saudi Endod. J., vol. 9, no. 1, pp. 27-33, 2019, doi: 10.4103/sej.sej_38_18.

[9] R. M. Clarkson, H. M. Podlich, N. W. Savage, and A. J. Moule, "A survey of sodium hypochlorite use by general dental practitioners and endodontists in Australia," Aust. Dent. J., vol. 48, no. 1, pp. 20-26, Mar. 2003, doi: 10.1111/j.1834-7819.2003.tb00004.x.

[10] H. Jungbluth C. Peters, O. Peters, B. Sener, and M. Zehnder, "Physicochemical and pulp tissue dissolution properties of some household bleach brands compared with a dental sodium hypochlorite solution," J. Endod., vol. 38, no. 3, pp. 372-375, Mar. 2012, doi: 10.1016/j.joen.2011.12.013.

[11] E. A. Saberi, N. Farhad-Mollashahi, and M. Saberi, "Difference between the actual and labeled concentrations of several domestic brands of sodium hypochlorite," Iran. Endod. J., vol. 14, no. 2, pp. 139-143, 2019, doi: 10.22037/iej.v14i2.23120.

[12] S. V. van der Waal, N. E. van Dusseldorp, and J. J. de Soet, "An evaluation of the accuracy of labeling of percent sodium hypochlorite on various commercial and professional sources: Is sodium hypochlorite from these sources equally suitable for endodontic irrigation?" J. Endod., vol. 40, no. 12, pp. 2049-2052, Dec. 2014, doi: 10.1016/j.joen.2014.08.021.

[13] A. A. Jawami, E. Soo, D. Abdullah, A. K. C. Liew, and M. Abd Rahman, "Metal contamination and stability of household bleach and specially-formulated sodium hypochlorite for endodontic use," Sains Malays., vol. 51, no. 1, pp. 307-313, 2022, doi: 10.17576/jsm-2022-5101-25.

[14] R. M. Clarkson, A. J. Moule, and H. M. Podlich, "The shelf-life of sodium hypochlorite irrigating solutions," Aust. Dent. J., vol. 46, no. 4, pp. 269-276, Dec. 2001, doi: 10.1111/j.1834-7819.2001.tb00291.x.

[15] B. J. Chaúque and M. B. Rott, "Photolysis of sodium chloride and sodium hypochlorite by ultraviolet light inactivates the trophozoites and cysts of Acanthamoeba castellanii in the water matrix," J. Water Health, vol. 19, no. 1, pp. 190-202, Feb. 2021, doi: 10.2166/wh.2020.401.

[16] B. M. B. Costa, et al., "Evaluation of ph stability, concentration and antimicrobial activity in commercial brands of sodium hypochlorite solution," Res. Soc. Dev., vol. 10, no. 3, pp. e54910313658, 2021, doi: 10.33448/rsd-v10i3.13658.

[17] M. A. Zazouli, Y. Hashempour, and N. Dashtban, "Investigation the effect of environmental factors on the sodium hypochlorite solution stability as disinfection of environmental surfaces," J. Mazandaran Univ. Med. Sci., vol. 33, no. 227, pp. 274-286, Nov. 2023. Available: http://jmums.mazums.ac.ir/article-1-19499-en.html

[18] B. Pişkin and M. Türkün, "Stability of various sodium hypochlorite solutions," J. Endod., vol. 21, no. 5, 253-255, May 1995, doi: 10.1016/S0099-2399(06)80991-X.
[19] Center for Disease Control and Prevention. (2024). Cleaning and disinfecting with bleach. [Online]. Available: https://www.cdc.gov/hygiene/about/cleaning-and-disinfecting-with-bleach.html
[20] B. R. Johnson and N. A. Remeikis, "Effective shelf-life of prepared sodium hypochlorite solution," J. Endod., vol. 19, no. 1, pp. 40-43, Jan. 1993, doi: 10.1016/S0099-2399(06)81040-X.
[21] C. K. Gow, C. Weinhouse, G. O. Johnson, and K. E. Saunders, "Stability of free available chlorine levels in dilute sodium hypochlorite solutions over a 6-week period," J. Am. Assoc. Lab. Anim. Sci., vol. 61, no. 2, pp. 181-187, Mar 2022, doi: 10.30802/AALAS-JAALAS-21-000080.
[22] C. Boutsioukis, B. Verhaagen, M. Versluis, E. Kastrinakis, P. R. Wesselink, and L. W. M. van der Sluis, "Evaluation of irrigant flow in the root canal using different needle types by an unsteady computational fluid dynamics model," J. Endod., vol. 36, no. 5, pp. 875-879, May 2010, doi: 10.1016/j.joen.2009.12.026.
[23] C. Boutsioukis, et al., "The effect of needle insertion depth on the irrigant flow in the root canal: evaluation using an unsteady computational fluid dynamics model," J. Endod., vol. 36, no. 10, pp. 1664-1668, Oct. 2010, doi: 10.1016/j.joen.2010.06.023.
[24] C. Boutsioukis and P. G. Nova, "Syringe irrigation in minimally shaped root canals using 3 endodontic needles: A computational fluid dynamics study," J. Endod., vol. 47, no. 9, pp. 1487-1495, Sep. 2021, doi: 10.1016/j.joen.2021.06.001.
[25] C. Boutsioukis, Z. Psimma, and E. Kastrinakis, "The effect of flow rate and agitation technique on irrigant extrusion ex vivo," Int. Endod. J., vol. 47, no. 5, pp. 487-496, May 2014, doi: 10.1111/iej.12176.
[26] M. Khare, B. S. Suprabha, A. Yadav, R. Shenoy, K. Boaz, and A. Rao, "Effectiveness of ultrasonic and manual dynamic agitation techniques in irrigant penetration: An in vitro study," World J. Dent., vol. 8, no. 3, pp. 207-212, 2017, doi: 10.5005/jp-journals-10015-1439.
[27] R. S. Kumar, et al., "Effectiveness of various irrigant activation techniques on the penetration of sodium hypochlorite into lateral canals of mature permanent teeth: A systematic review and meta-analysis," Saudi Dent. J., vol. 35, no. 1, pp. 1-23, Jan. 2023, doi: 10.1016/j.sdentj.2022.12.004.
[28] F. Puleio, A. S. Lizio, V. Coppini, R. Lo Giudice, and G. Lo Giudice, "CBCT-based assessment of vapor lock effects on endodontic disinfection," Appl. Sci., vol. 13, no. 17, pp. 9542, Aug. 2023, doi: 10.3390/app13179542.
[29] P. P. Machtou, "Manual dynamic activation technique," Clin. Dent. Rev., vol. 2, pp. 1-5, Sept. 2018, doi: 10.1007/s41894-018-0034-4.
[30] S. Paixão, P. S. Gomes, M. H. Fernandes, C. Rodrigues, and L. Grenho, "Comparative evaluation of ultrasonic and sonic irrigant activation systems: Assessing extrusion risk, debridement, and biofilm removal in distinct apical preparation sizes," Appl Sci., vol. 14, no. 9, pp. 3904, Jan. 2024, doi: 10.3390/app14093904.
[31] X. Zou, X. Zheng, Y. Liang, C. Zhang, B. Fan, J. Liang, J. Ling, Z. Bian, Q. Yu, B. Hou, and Z. Chen, "Expert consensus on irrigation and intracanal medication in root canal therapy," Int. J. Oral Sci., vol. 16, no. 1, pp. 23. Mar. 2024, doi: 10.1038/s41368-024-00280-5.
[32] D. J. Kleier, R. E. Averbach, and O. Mehdipour, "The sodium hypochlorite accident: experience of diplomates of the American Board of Endodontics," J. Endod., vol. 34, no. 11, pp. 1346-1350, Nov. 2008, doi: 10.1016/j.joen.2008.07.021.