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Original article

Knowledge, Attitude, and Practice of Libyan General Dentists and Specialists toward Cavity Disinfectants before Composite Restorations: A Cross-sectional Survey

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Abstract
The innovative approach for dental caries management focuses on the maximum removal of bacteria from the carious lesion, while minimizing loss of tooth tissue. The use of cavity disinfectants effectively reduces the number of viable remaining bacteria. The present study aims to evaluate and compare the knowledge, attitude, and practice of different types of cavity disinfectants among Libyan general dentists and specialists. A cross-sectional online survey involving 151 dentists was carried out in Benghazi (Libya) using a validated 10-item questionnaire. Data were analyzed using chi-square tests, with significance set at $p<0.05$. Results showed that chlorhexidine (CHX) and sodium hypochlorite (NaOCl) are the most popular disinfectants, there was a statistically significant difference in regard of knowledge of participating groups toward (NaOCl), (EDTA) and hydrogen peroxide. The majority of the participants indicated the use of a cavity disinfectant before acid etching, and believed it can be applied for both shallow and deep cavities. The majority of the participants didn't attend any lectures concerned of cavity disinfection; however, they expressed a positive attitude toward the effectiveness of them against bacteria. There was no significant difference between participating groups in regard of cavity disinfectant's daily practice; the most commonly used disinfectants are CHX followed by NaOCl. The selection of a suitable disinfectant necessitates the understanding of disinfection mechanisms and their effects on the bond strength of the restorative material.
Keywords: Cavity Disinfectant, CHX, NaOCl, Antibacterial Adhesive System, MDPB.

Introduction

Resin composites are currently the most widely used restorative materials in dentistry [1], Researchers are working continuously to enhance their durability and reliability with minimized risk of failure [2]. Literature revealed that dental restorations fail primarily due to secondary caries [2,3] and fracture [2,4]. It is well documented that composite restorations tend to accumulate more biofilm compared to other types of dental restorations [1,3,5]. Additionally, their polymerization shrinkage, increases the susceptibility of composite restorations to recurrent caries [3,6].

The old concept considers caries as a progressive process [2], which demands complete caries excavation in the entire cavity, it is currently unacceptable because it compromises the biomechanical integrity of the tooth structure [2]. To avoid damage to the dental pulp complex [1,2], and to promote the preservation of the tooth structure, there is a trend to use the minimally invasive and conservative approaches [1,2]. These include stepwise and partial caries removal [2], especially in clinical situations of deep carious lesions [5].

Despite these approaches, it has been reported that it is impossible to remove all microorganisms; some bacteria can persist even after all soft dentin is excavated [7]. Studies revealed that after cavity preparation, only a small section of the cavity remains disinfected [6]. Bacterial residues in the cavity walls can impact the efficacy of restorative treatment; they can grow, particularly in the existence of microleakage [4, 6,8], and preserve their activity, even inside the dentin, for more than a year [9]. Microbial growth beneath dental restorations has been considered a significant biological problem in dentistry [10], which is responsible for caries recurrence, increased pulp sensitivity (post-operative sensitivity), pulpal inflammation, and marginal discoloration [8,11].

The innovative approach for dental caries management focuses on the maximum removal of bacteria from the carious lesion [10,12], while minimizing loss of tooth tissue [12]. Consequently, the using of cavity cleansers in such cases can provide antibacterial and antiproteolytic activities, effectively reducing the number of viable remaining bacteria [2]. In the early 1970s Brännström and Nyborg recommended that the cavity preparation be cleaned before placing the restoration, which sparked interest in the study of antimicrobial agents and their effects on the pulp [13]. A cavity disinfectant must be bactericidal and/or bacteriostatic, biocompatible, and easy to acquire and handle. It needs to be effective without compromising dentin bond strength [14]. However, the interaction between adhesive systems and cavity disinfectants is a controversial issue in restorative dentistry [7]. The effects mentioned above depend on each disinfectant's characteristics, the type of substrate, the adhesive system, and the restorative material used [14]. For instance, there is a greater need to disinfect the cavity in the self-etch bonding systems due to the absence of the irrigation step and removal of the smear layer [9,15].

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Various antibacterial agents can be used as cavity disinfectants, such as chlorhexidine (CHX), sodium hypochlorite (NaOCl), fluoride-based solutions, benzalkonium chloride (BAC) [7,9] hydrogen peroxide (H_2O_2), disodium ethylene diamine tetra acetic acid (EDTA) [7].
CHX is expected as the gold standard antimicrobial agent owing to its broad-spectrum antimicrobial action against a wide range of gram-positive and gram-negative bacteria [4,12], especially against gram-positive bacteria such as streptococcus mutans. Chlorhexidine acts as an antiplaque agent owing to its ability to inhibit the formation of the acquired pellicle [4]. The literature reveals that CHX is an efficient chemotherapeutic agent that contributes to the reduction of residual bacteria after cavity excavation [7,10,12]. CHX is a matrix metalloproteinase (MMP) inhibitor [7]; which has been reported to inhibit the activities of MMP-2, MMP-8, and MMP-9 [10]. Chlorhexidine gluconate in CHX binds to the amino acids in dentin and its bactericidal action lasts several hours. Multiple studies have reported that CHX significantly decreases the number of S. mutans. A 2% solution of CHX is bactericidal by precipitating cytoplasmic contents and leading to cell death [7]. For etch-and-rinse adhesives, CHX can be applied to the dentin directly or incorporated into an acidic conditioner before the application of adhesives [10]. NaOCl is also widely used in dental procedures due to its proteolytic and disinfectant properties [4,7]. Which alters cellular metabolism and destroys phospholipids. It also promotes the formation of chloramines, inactivating bacterial enzymes irreversibly [7]. It also has the highest antimicrobial activity against anaerobic bacteria, as well as against Streptococcus mutans [4]. The present cross-sectional study aims to evaluate and compare the knowledge, attitude, and practice of different types of cavity disinfectants among Libyan general dentists and specialists.

Methods

Study design and setting

The present study was a descriptive cross-sectional study. The survey was carried out in Benghazi (Libya) during 2024. Dentists were invited randomly among the dentists who have registered successfully as members of the Libyan Dental Association. The study was conducted through an online survey which was distributed directly through email and social media applications. The purpose of the study and the anonymous processing of the data were explained to all participating dentists.

Data collection

The study involved 151 general practitioners and specialists working in polyclinics, private clinics, and dental schools in Libya. The questionnaire used in the present study was designed based on a previous study regarding cavity disinfectants [16]. It consisted of 10 closed-ended questions organized into two sections. The first section deals with demographic information (items 1-3), which included gender, clinical experience, and qualification of participants. Whereas, the second section divided into three parts: the first part (items 4-6) assessed the dentists' general knowledge about cavity disinfectants, including the types of cavity disinfectant currently used in dentistry, when and where to use them. The second part (items 7-8) evaluated the dentists' attitude toward the cavity disinfectants; the participants were asked if they had attended any lectures regarding cavity disinfection and their thought about the effectiveness of the cavity disinfectant against bacteria. The third part (items 9-10) evaluated the daily practice of cavity disinfectants; the participants were asked if they use them before composite restoration or not and if yes, they had to identify which type do they use. The questionnaire was first piloted on four experts in a local setting (two endodontists, and two operative dentistry specialists). As a result of comments from these experts, minor modifications were made before it was utilized in the current study. Approval from the ethics committee of the Faculty of Dentistry, Benghazi University, Libya was obtained (Protocol No. 0184).

Statistical analysis

The survey data were statistically analyzed using Statistical Package for Social Science (SPSS). The chi-square test was used to find out the relationship between the tested study's parameters and the qualification of participants with level of statistical significance set at $p<0.05$.

Results

Demographic Data

A total of 151 respondents, according to gender; most of them are females 125(82.8%). Regarding years of experience in dentistry, 34(22.5%) of participants had ≤5 years of experience as a dentist, while 51(33.8%) had 6-10 years of experience. The majority of respondents 66(43.7%) had >11 years of experience. The majority 67(44.4%) of the study participants were general dental practitioners, 25(16.6%) were restorative and endodontic specialists, 22(14.6%) were fixed prosthodontist/ pedodontist, and 37(24.5%) were other specialties. Descriptive statistics of the participants are shown in table 1.

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Table 1. The demographic data of the participants.

Demographic Data		Numbers	(%)
Gender	Male	26	(17.2 %)
	Female	125	(82.8 %)
Experience	≤5 years	34	(22.5 %)
	6-10 years	51	(33.8 %)
	>11 years	66	(43.7 %)
Qualification	General Dentist	67	(44.4 %)
	Restorative/ endodontic specialist	25	(16.6 %)
	Fixed prosthodontist/ pedodontist	22	(14.6 %)
	Other specialties	37	(24.5 %)

Dentists' knowledge about cavity disinfectants

The response of the participating dentists to the question of which of the following materials can be used as cavity disinfectant? The most chosen material was CHX 70.2%, followed by NaOCl, 55%. Only 10.6% of them were don't know the answer (Table 2).

Table 2. The response of the participants to the types of cavity disinfectants.

Item	Answers Options	Number	Percent (%)
Q1. Which of the following materials can be used as cavity disinfectant?	CHX	106	70.2%
	Fluoridated agents	15	9.9%
	NaOCl	83	55%
	EDTA	12	7.9%
	Phosphoric acid	23	15.2%
	Hydrogen Peroxide	31	20.5%
	Benzalconium chloride	7	4.6%
	Normal saline	33	21.9%
	Antibacterial adhesive system	10	6.6%
	I don't know	16	10.6%

There was no significant difference between participating groups regarding CHX; (88%) of restorative/ endodontic specialists agree with that CHX can be used as a cavity disinfectant. However, they differ significantly regarding knowledge of NaOCl; only (35.1%) of other specialties group agree with that NaOCl is a cavity disinfection material. Furthermore, the participating groups differ significantly in their response toward (I do not know); (0 %) of restorative/endodontic specialists do not know the answer reflecting the highest knowledge of them towards the listed types of cavity disinfectants (Table 3).

Table 3. The overall response to type of material which can be used as cavity disinfectant?

Items	Answers Options	Qualification				P-value
		General dentist (n=67)	**Restorative/ endodontic specialist** (n=25)	**Fixed prosthodontist/ pedodontist** (n=22)	**Other specialties** (n=37)	
Q1. Which of the following materials can be used as cavity disinfectant?	**CHX**	45(67.2%)	22(88%)	17(77.3%)	22(59.5%)	0.084
	Fluoridated agents	9(13.4%)	2(8%)	1(4.5%)	3(8.1%)	0.599
	NaOCl	38(56.7%)	18(72%)	14(63.6%)	13(35.1%)	0.023*
	EDTA	3(4.5%)	0(0%)	3(13.6%)	6 (16.2%)	0.053*
	Phosphoric acid	14(20.9%)	3(12%)	3(13.6%)	3(8.1%)	0.339
	Hydrogen Peroxide	13(19.4%)	1(4%)	8(36.4%)	9(24.3%)	0.047*
	Benzalconium chloride	1(1.5%)	3(12%)	2(9.1%)	1(2.7%)	0.118
	Normal saline	13(19.4%)	6(24%)	4(18.2%)	10(27%)	0.788
	Antibacterial adhesive system	2(3%)	3(12%)	1(4.5%)	4(10.8%)	0.283
	I don't know	6(9%)	0(0%)	2(9.1%)	8(21.6%)	0.047*

The response to the question related to the timing of the cavity disinfection procedure, the majority of the participants indicated the use of a cavity disinfectant before acid etching. However, there was a significant difference between participating groups, only (59.5%) of other specialties indicated the use of disinfectants

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before acid etching, and (27%) of them don't know the correct answer. In addition, (84%) of restorative/ endodontic specialists believe cavities have to be disinfected before acid etching, the rest of them believe cavity should be disinfected after acid etching, and (0%) don't know the answer (Figure 1).

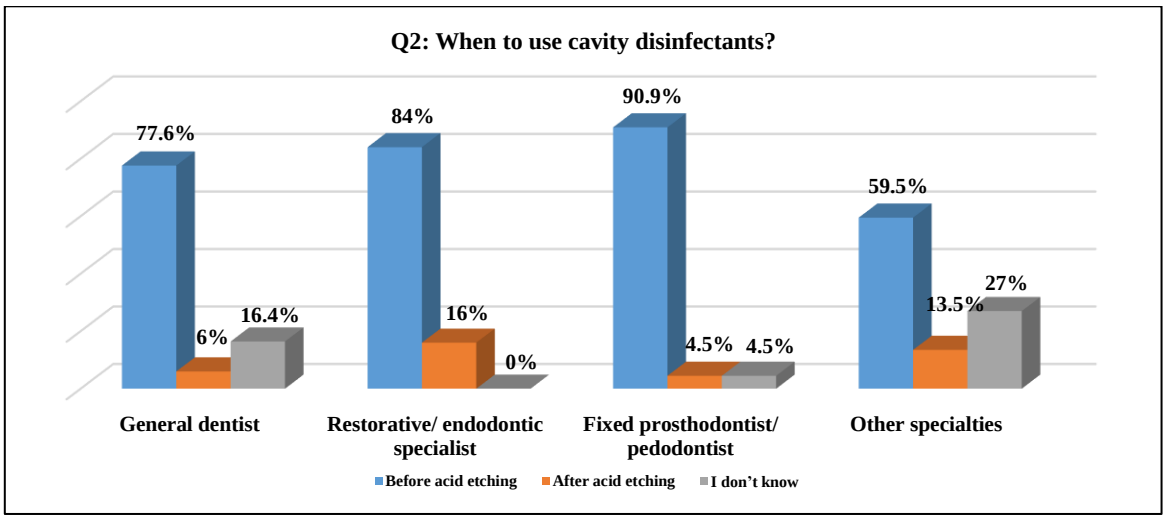

Figure 1. The response to the time of cavity disinfection procedure application (P value 0.023)

Regarding the question, where to use cavity disinfectants? There was no significant difference between research groups, the majority of each group was aware of disinfecting both shallow and deep cavity before composite restoration without preference (cavity depth). The response of the participants toward using disinfection in a shallow cavity, the highest response was reported for the fixed prosthodontist/pedodontist group. Furthermore, general dentists never believe in using disinfectants in deep cavities, this is reflected from (0%) responses. (27%) of other specialties don't know the correct answer (Figure 2).

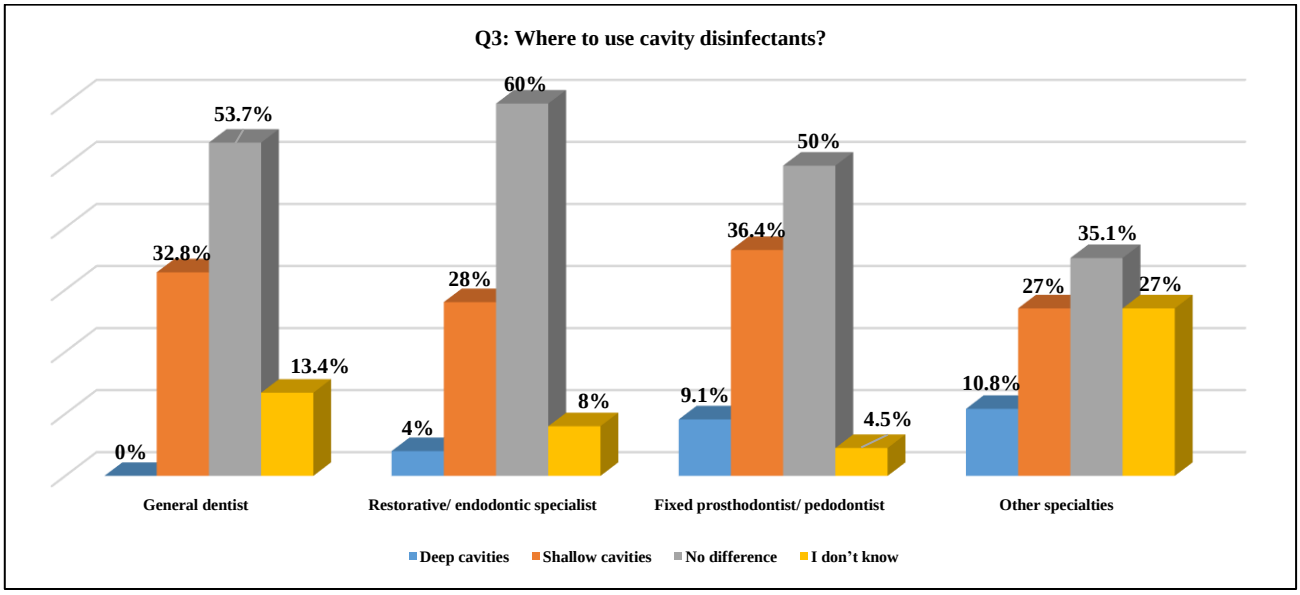

Figure 2. The response to the depth of the cavity where disinfectants can be used (P value = 0.062)

Dentists' attitude about cavity disinfectants

The majority of the participating dentists didn't attend any lectures concerning cavity disinfection; the highest percentage was reported for fixed prosthodontist/pedodontist and other specialties (86.4%, 86.5%) respectively. While the current study shows that (32%, 31.3%) of restorative/ endodontic specialists and general dentists, respectively were taught about cavity disinfectants (Figure 2).

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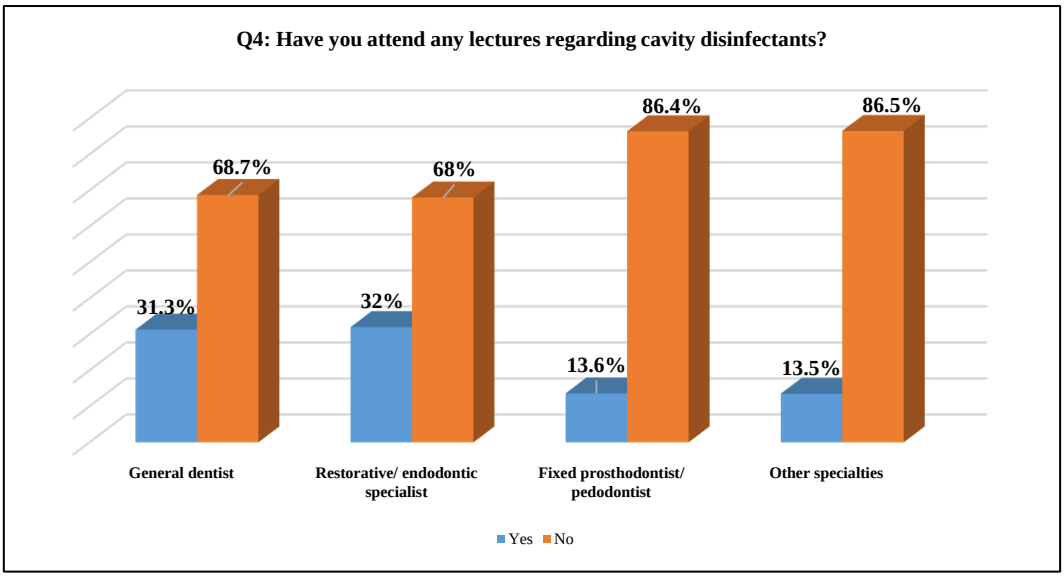

Figure 3: The response to attending lectures regarding cavity disinfection (P value= 0.099)

There was no significant difference between participating groups regarding the effectiveness of cavity disinfectants against bacteria; (90.9%) of fixed prosthodontist/pedodontist believe in the effectiveness of cavity disinfectants against bacteria. Three-quarters of other specialties were aware that cavity disinfectants are effective against bacteria, with (21.6%) of them don't know the answer (Figure 4).

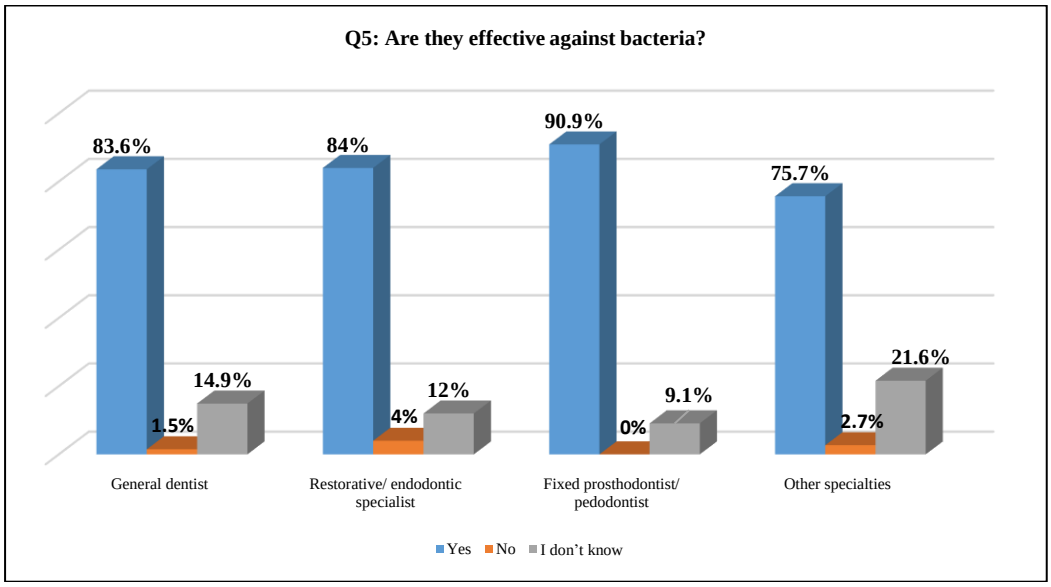

Figure 4. The attitude of participating dentist toward effectiveness of cavity disinfectants against bacteria (P value= 0.777)

Dentists' Daily Practice of Cavity Disinfectants

There was no a statistically significant difference between participating groups toward the question of (Do you use cavity disinfectants in your daily practice?). In respect of the following groups: general dentists, fixed prosthodontist/pedodontist, other specialties; more than half of each group is not using cavity disinfectant in their daily practice (55.2%, 63.6%, and 64.9% respectively). In contrast, more than half of restorative / endodontic specialists (60%) are using disinfectant in their daily practice (Figure 5).

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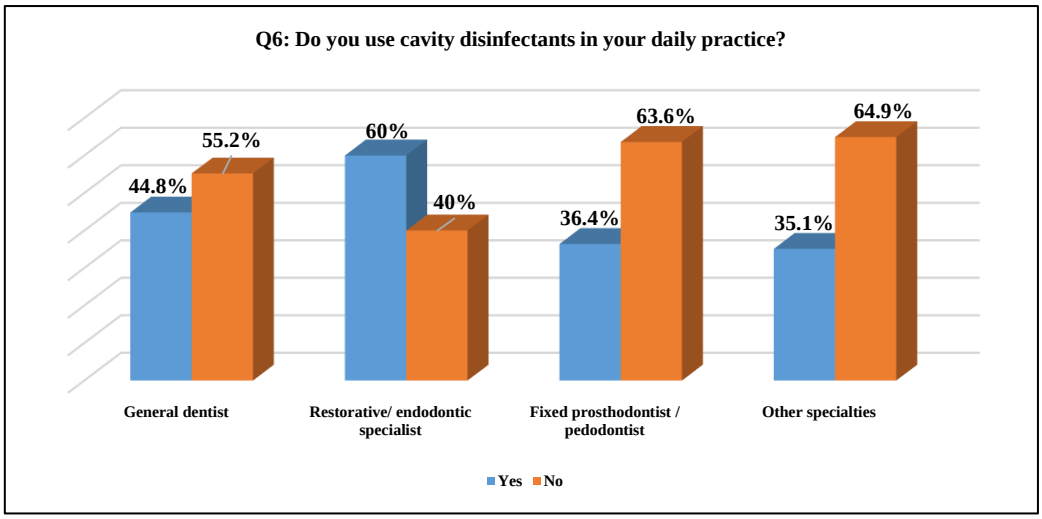

Figure 5. The response of participants to daily practice of cavity disinfectants. (P value= 0.229)

According to the overall response to the last question in the questionnaire, the most commonly used cavity disinfectants are CHX (45%), followed by NaOCl (35.1%) and normal saline (19.9%). In contrast, the least used materials are: benzalkonium chloride, antibacterial adhesive system, fluoridated agent, phosphoric acid, and EDTA (0.7%, 2%, 2.6%, 7.3%, and 7.9%), respectively (Table 4).

Table 4: The response of the participants to materials they are use as cavity disinfectant.

Items	Answers options	N	%
Q7: Which of the following materials are you using as a cavity disinfectant?	CHX	68	45%
	Fluoridated agents	4	2.6%
	NaOCl	53	35.1%
	EDTA	12	7.9%
	Phosphoric acid	11	7.3%
	Hydrogen peroxide	21	13.9%
	Benzalkonium chloride	1	0.7%
	Normal saline	30	19.9%
	Antibacterial adhesive system	3	2%

The comparison between general dentists and specialists toward daily practicing of different types of cavity disinfectant, showed no significant difference between them. Additionally, the result shows that general dentists use all the materials present in the list except benzalkonium chloride (0%). Restorative/ endodontic specialists preferred using only CHX, NaOCl, phosphoric acid, and normal saline, with (0%) response toward other materials. Regarding fixed prosthodontist/ pedodontist group, they didn't prefer to use fluoridated agents, benzalkonium chloride, and antibacterial adhesive system (Table 5).

Table 5: The comparison between general dentists and specialists daily practicing of cavity disinfectant.

Items	Answers options	Qualification				P-value
		General dentist	Restorative/ endodontic specialist	Fixed prosthodontist/ pedodontist	Other specialties	
Q7: Which of the following materials are you using as a cavity disinfectant?	**CHX**	32(47.8%)	14(56%)	8(36.4%)	14(37.8%)	0.414
	Fluoridated agents	2(3%)	0(0%)	0(0%)	2(5.4%)	0.494
	NaOCl	29(43.3%)	7(28%)	7(31.8%)	10(27%)	0.297
	EDTA	8(11.9%)	0(0%)	1(4.5%)	3(8.1%)	0.265
	Phosphoric acid	5(7.5%)	1(4%)	3(13.6%)	2(5.4%)	0.591
	Hydrogen peroxide	13(19.4%)	0(0%)	2(9.1%)	6(16.2%)	0.097
	Benzalkonium chloride	0(0%)	0(0%)	0(0%)	1(2.7%)	0.376
	Normal saline	12(17.9%)	5(20%)	6(27.3%)	7(18.9%)	0.816
	Antibacterial adhesive system	2(3%)	0(0%)	0(0%)	1(2.7%)	0.707

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Discussion

Bacterial activity has proved to be the main causative factor for placement and replacement of restorations. It was confirmed histologically that fermentative organisms remained viable under non-antiseptic restorations for as long as 139 days. Furthermore, bacteria present in the smear layer can multiply, allowing their toxins and degradation products to diffuse into the pulp resulting in irritation and inflammation [17]. During the tooth preparation stage, it is not possible to completely eliminate bacteria from the cavity, even with the use of disclosing dyes [9]. Previous studies [18,19] have shown that clinicians strongly agree that complete caries removal is necessary for dentin caries treatment, however, the use of antisepsis techniques before dental fillings may encourage the selective removal of carious tissue to conserve dental hard tissues and maintain the dentin still prone to remineralization [20]. The concept of disinfecting the cavity after preparation has become popular with a variety of commercially available dentin disinfectants launched into the market. An ideal cavity disinfectant must be biocompatible, and easy to acquire and handle. It needs to be capable of correctly disinfecting the cavity without compromising dentin bond strength [4]; if the sealing ability is disrupted, marginal leakage may occur. The occurrence of leakage between restorative material and teeth may decrease the longevity of the restoration [21]. In a recent clinical study, Kaya et al. [22] demonstrated that disinfecting the cavity preparation before placing resin composites significantly reduced the incidence of postoperative sensitivity. Both in vivo and in vitro studies demonstrated that Cavity Cleanser effectively reduced microorganisms in contaminated dentin [23].

The primary objective of this study was to evaluate the knowledge, attitude, and practice of different types of cavity disinfectants among Libyan general dentists and specialists. A cross-sectional study was conducted using a reliable and valid questionnaire designed to be easy to read and straightforward to complete. The survey was carried out online. Hopefully, this will increase participation in this study. Several studies have been conducted in respect of cavity disinfectants covering them in many aspects. However, the survey-based researches about cavity disinfectants are rare, only one study with a similar aim of the present study was found [16]. In 2022 Naveen designed a KAP survey on knowledge, attitude and practice of cavity disinfectants among dental practitioners but the content of the study was different from the questionnaire used in the current study. Hence, it is difficult to compare with. In the present study, 82.8% (125 of 151) of the participants were female. This high percentage may be attributed to the highest proportion of females currently graduating from Libyan dental schools. Additionally, females were more encouraged to fill out the questionnaire than males. A similar sample feminization was observed in other survey conducted in Libya [24]. Qualification is an important aspect of this study, almost half of participants were general dentists 44.4% (67 of 151).

To assess the awareness of participating dentists regarding different types of cavity disinfectants, the first question is designed as a multiple-choice question with more than one answer that could be chosen, the list includes the majority of popular cavity cleansers discussed in the previous literatures, with the last option was "I don't know". The result shows that approximately three quarter of the participating dentists were aware that (CHX) is used as a cavity disinfectant 70.2% (106 of 151), and more than half of them were aware of the use of (NaOCl) as a cavity disinfectant 55% (83 0f 151), this was in agreement with previous studies which stated (CHX) and (NaOCl) is most popular cavity disinfectants [4, 25]. (CHX) has been used as an oral antimicrobial agent since the 1970s. Presently, it is one of the most widely used antimicrobial agents in oral health and is considered the "gold standard" of oral antiseptics [26]. (CHX) effectively inhibits the formation and progression of dental plaque [4, 26]; it has a broad spectrum of antibacterial action, especially against gram-positive bacteria like Streptococcus mutans which is the main initiator of dental caries [4, 27]. Tazegül et al. (2006) found that solutions containing chlorhexidine gluconate caused a decrease in the amount of plaque S. mutans and this situation continued in 3-month controls [28]. (CHX) has been suggested as an effective agent for the disinfection of the prepared cavity before restorative procedures. Can enhance the longevity of dental restorations by minimizing the risk of bacterial contamination. Its antibacterial properties make it particularly useful in reducing the presence of residual cariogenic bacteria that can lead to secondary caries and restoration failure [9]. It has the ability to remove the loose smear debris and therefore, increases the surface energy of dentin, which in turn increases the wetting ability of primers [17]. Sodium hypochlorite is also one of the most commonly used cavity disinfectants in clinical practice, due to its antibacterial action and wettability property [4, 25]. It has the highest antimicrobial activity against anaerobic bacteria as well as against Streptococcus mutans [4], and residual bacteria [26]. Additionally, (NaOCl) has been well documented as having excellent tissue-dissolving action that have first been used in (1920) in endodontics as an antimicrobial irrigant [26]. Upon contact with the dentin surface, (NaOCl) breaks down to sodium chloride and oxygen, causing an oxidation process in the dentin matrix [26]. Furthermore, it deproteinizes both demineralized and mineralized dentin [25]; i.e., nonspecific proteolytic action [29]. A comparison between the research groups, the results showed no statistically significant difference in knowledge about the different types of cavity disinfectants regarding (CHX), fluoridated agent, phosphoric acid, benzalkonium chloride (BAC), normal saline, antibacterial adhesive system (p- value >0.05). Reflecting the same level of knowledge about these materials among general dentists and specialists.

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However, only 35.1% of other specialties group agreed with (NaOCl) use for cavity disinfection indicating the lowest knowledge toward (NaOCl) among the participating groups; this may be correlated to the fact that this group of dentists is not specialized in treating teeth affected by carious or non-carious lesions. Furthermore, there was a statistically significant difference regarding the option (I don't know).

Currently, combinations of chlorhexidine with other antibacterial agents are commercially available; for example, a combination with fluoride or thymol. Fluoride is the most popular anti-caries agent in dentistry. Its antibacterial activity has been demonstrated many times [30]. Fluoride is not designed specifically for cavity disinfection, but some properties of fluoride such as its ability to inhibit the active growth of cariogenic bacteria, remineralize the affected dentin, and increase the microhardness of dentin were thought to make it usable as a cavity disinfectant [31]. Therefore, fluoridated agents help to diminish the development of secondary caries [4]. Another form of fluoridated agent is Tubulicid Red Label contains 1% sodium fluoride, 0.2% (EDTA), and 0.1% (BAC). Tubulicid Red Label, which is frequently preferred in cavity disinfection and fluoride surface cleaning, helps to remove debris without opening the dentin tubules during preparation [32]. The results of the present study revealed that the majority of participants didn't aware about the use of fluoridated agents in cavity disinfection; the percentage of awareness was range from (4.5%) for fixed prosthodontist/ pedodontist to (13.4%) for general dentists.

Ethylene diamine tetra acetic acid (EDTA) is an organic mild chelator compound [4], achieves moderate dentine demineralization by removing the smear layer. It avoids the denaturation of collagen and maintains the hybrid layer quality due to the existence of residual hydroxyapatite crystals within the collagen matrix [25]. For the purpose of cavity disinfection (EDTA) is available in the market as commercial compound known as Tubulicid (Global Dental Products, Bellmore, NY, USA) is a quaternary ammonium compound (benzalkonium chloride) with (EDTA) that comes in three forms: Tubulicid Red, as mentioned before, contains 1.0% sodium fluoride, which has been recommended by the manufacturer to be used for cleaning without removing the smear layer. Tubulicid Blue without fluoride is used to disinfect the whole tooth prior to the cementation of crowns or bridges and Tubulicid Plus has been claimed to be a stronger cleaner and used as a root canal irrigant to remove the smear layer and open dentinal tubules [26]. The result of current study reported that only 7.9% (12 of 151) of participants believe in using (EDTA) for cavity disinfection before composite restoration. There was a statistically significant difference between research groups; none of the restorative and endodontic specialists (0%) agreed with the use of (EDTA) for cavity disinfection.

Hydrogen peroxide is an antibacterial agent that has been regaining attention in recent years. It is an active agent that affects a wide range of organisms such as bacteria, yeast, fungi, viruses and spores. Scrubbing the cavity walls with 2% or 3% (HP) on a pellet of cotton is a common method for cleaning the cavity walls before placement of any restorative material. Besides its antibacterial activity, another advantage of (H_2O_2) is its bubble action that may help to produce clean cavity walls [33]; so it is used in cavity cleaning to prevent tooth color changes that may occur after root canal filling [32]. In our study, (20.5%) of the practitioners were indicated the use of hydrogen peroxide as cavity disinfectant, there was a statistically significant difference between participating groups (p-value<0.05). Only 4% (1 of 151) of restorative/ endodontic specialists was believe in using it for cavity disinfection.

Benzalkonium chloride (BAC); is a disinfectant from quaternary ammonium compounds with antiseptic effect and is used in concentrations of (0.4-1.6%). (BAC) removes the smear layer without opening the dentinal tubules [27]. Unlike (CHX), (BAC) is stable in acidic media and has been added into some commercial phosphoric acid etchants to a final concentration of (1%) [23]. Chan in (1994) reported that dentine disks acid-etched with 37% phosphoric acid containing 1% (BAC) exhibited a zone of bacterial inhibition around the disk [34]. Thus, Arzu Tezvergil-Mutluay et al. concluded that (BAC) can inhibit matrix metalloproteinases (MMPs), thereby preserving the dentin-resin bonded interface. In the current study, only (4.6%) of the participants knew that (BAC) can be used for cavity sterilization. This finding is in agreement with the previous study by Turkun et al., which concluded that although (BAC) has been described as a strong antibacterial agent against microorganisms like S. mutans, Streptococcus salivarius, and S. aureus, however, its antibacterial activity is reported to be less effective than that of (CHX) [35].

Regarding phosphoric acid only (15.2%) of all participating general dentists and specialists thought it could be used for cavity disinfection, there was no statistically significant difference between research groups (p-value>0.05), and the highest reported value was less than one quarter (20.9%) of general dentists. The result reveals low percentage of participants believe the additional cavity disinfection step was an unnecessary procedure. In spite of the old observation of Settembrini et al. (1997); which stated that acid etching and rinsing procedures are able to remove the residual bacteria from the cavity preparation [36], Brescianiet al. suggested a potentially beneficial, inhibitive effect of dentin acid etching procedures is restricted on residual S. mutans underneath composite restorations [37]. Furthermore, turkun et al. (2006) observed that certain bacteria are acid tolerant and the dentin itself acts as a buffer, limiting the acid action. So, the antibacterial activity of acid etchants is probably less than disinfectants that have substantive antibacterial activity [33].

Dentine bonding agents have gone through many changes over the last 10 years [38]. Antibacterial agents could be added to adhesive system, which include leachable compounds, polymerizable monomers, and filler particles. An approach of leaching antibacterial agents has not been well accepted from the clinical point of

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view, as the release of the agents result in a limited period of effectiveness and deterioration of restoration over time [39]. In an attempt to overcome the disadvantage of leachable agents (burst effect), Imazato et al. introduced the concept of the immobilized bactericide into dentistry. This technology is more advantageous in terms of longevity of effects and maintaining the mechanical properties of carrier materials [39]. Polymerizable antibacterial agents are immobilized in the resin matrix system upon polymerization, enabling long-lasting antibacterial effects. A new monomer called methacryloyloxy dodecyl pyridinium bromide (MDPB), has been incorporated into a commercial dental adhesive (5% MDPB in Clearfil Protect Bond) and used in clinical practice [23]. Pinto et al. investigated the antibacterial effect of (MDPB) containing adhesive system and compared it with a non-MDPB-containing adhesive, they reported that Clearfil Protect Bond resulted in lower counts of total Streptococci as well as S. mutans than did a non-MDPB containing adhesive for enamel and dentin restorations [40]. The Clearfil Protect Bond self-etch primer showed bactericidal effects against a broad range of caries-related bacteria, including acid-resistant species [41]. In contrast, another study by de Carvalho et al., showed that the performance of Clearfil Protect Bond was similar to that of other non-MDPB containing adhesives in terms of caries formation, and that it did not inhibit secondary caries in a simulated high caries challenge [42]. (MDPB) containing primer was compared with three cavity disinfectants (CHX, BAC, 3%H_2O_2) in term of antibacterial activity by Turkun et al.; they observed more inhibition zones associated with the MDPB-containing primer than the others. They concluded that the MDPB-containing system could inactivate the bacteria in the cavity more effectively than the tested cavity disinfectants [33]. Although antibacterial adhesive systems have become popular nowadays with excellent clinical performance, unfortunately, the result of the current study revealed low knowledge of participating general dentists and specialists toward this material. Only 6.6% (10 of 151) believed in the existence of an antibacterial adhesive system.

The application sequence of the disinfectant is an important factor to consider. Some clinicians prefer to apply the disinfectant after cavity preparation and before the acid etching, whereas others prefer to apply it after the etching. Additionally, some clinicians prefer to rinse off the disinfectant before the bonding procedure, whereas others do not. Perdigao et al. (1994) applied the disinfectant after the smear layer removal by using the all-etch technique and they did not find any decrease in the shear bond strength to dentin. Conversely, Cao et al. (1995) reported that the disinfectants decreased shear bond strength to dentin. However, the degree of decrease was related to the brand of adhesive and disinfectant [43]. It appears there is a greater need for disinfecting the cavity especially in the self-etch bonding systems due to the absence of the rinsing step and removal of the smear layer [9].

In the present study, the response to the question of when to use cavity disinfectants? The majority of the participants believe that cavity disinfectants should be applied before acid etching. This finding was in contrast to other previous studies. For instance, Breschi recommends applying (CHX) on etched dentin before the bonding procedure for total etch system [44]. Cha and Shin (2016) recommended washing the cavity walls before applying the self-etch adhesive and after using 2% CHX to achieve better composite adhesion when using self-etch adhesive systems [45]. This is probably attributed to its higher affinity of bonding to the etched dentin than the mineralized dentin, as reported by researches [25]. Naenni et al. observed a lack of tissue dissolution capacity and removing smear layer by (CHX). Hence, the remaining smear layer acts as a potential barrier to minimizing the disinfectant's contact time with dentin [46]. The phosphoric acid etchant generates micro-pores on dentin surface, and removes smear layer which may enhance the penetration of the cavity disinfectant deeply into dentin. Matrix metalloproteinases (MMPs) in dentin have been shown to play a role in the degradation of unprotected collagen fibrils within the hybrid layer. It is thought that CHX's ability to inhibit (MMPs) found in acidified dentin increases the bonding strength and therefore, (MMPs) inhibitors such as (CHX) may prolong the bonding life of the adhesive to dentin [27]. Wakabayashi et al. observed that the treatment of dentin with 10% (NaOCl) after etching with 40% phosphoric acid enhanced the tensile strength of adhesive to dentin. Even after thermocycling (10,000 cycles at 4–60◦ C), the bond strength was 1.5 times higher than that recorded for etched dentin [29].

In our study, only (59.5%) of other specialties group in contrast to (90.9%) of fixed prosthodontist/ pedodontist group agreed with using disinfectants before acid etching. Regarding restorative/endodontic specialists, (84%) of them also believe that cavities have to be disinfected before acid etching, the rest of them believe cavity should be disinfected after acid etching, and 0% of them don't know the answer. A significant difference was observed among the research groups (p-value < 0.05). This discrepancy may be attributed to the decreased awareness of participants toward a better sequence of using cavity disinfectants, as well as their mechanism of action and their effect on the bond strength.

Nowadays there is a trend to use minimally invasive and conservative approaches; such as stepwise and partial caries removal, especially in clinical situations of deep carious lesions. Making a step of cavity disinfection more important in case of deep cavities than shallow cavities where caries can be removed completely. There are no previous studies support this claim. It was well documented that there are differences between superficial and deep dentin; superficial dentin, composed mainly of intertubular dentin, which has a higher percentage of collagen and a smaller number of dentinal tubules. The deep dentin, close to the pulp region, is formed mainly by dentinal tubules and presents a reduced percentage of intertubular

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dentin, mainly after acid etching [4]. Furthermore, the microbiota associated with dentinal caries exhibits a distinct bacterial community composition in comparison to enamel lesions. Lactobacilli have been reported to prevail in dentinal caries. Lactobacilli are acidogenic and aciduric bacteria that have been proposed to be involved more in the progression of caries rather than the initiation. Whereas bacteria from the superficial layers of caries have the host diet, usually rich in sugars, as an important source of nutrients, bacteria occurring at the deepest layers of caries may face a rather different condition. Deep dentinal caries lesions may be the primary source of bacteria for endodontic infections [47]. These novel findings highlight the importance of infection control in teeth with extremely deep carious lesions [48].

In the present study, the response to the third question of: where to use cavity disinfectant? Our findings revealed no significant difference between research groups (p-value>0.05), the majority of participants from all groups supported the use of disinfection procedures for both shallow and deep cavities, this thought may be contributed to the fact of presence of bacteria in either shallow and deep cavity regardless technique of cavity preparation, therefore, both of them need to be sterilized. The second high response was for shallow cavity. Furthermore, the response towards using of disinfectants in deep cavity range from (0%-10.8%). And the percentage of participants who do not know the answer range (4.5%-27%).

In the present study, the response of the participants toward the fourth question "Have you attended any lectures regarding cavity disinfectants?" The majority of respondents from all groups reported that they have not attended any lectures specifically on cavity disinfectants as a separate topic. This indicates self-education of our participants as the previous results in the present study showed good knowledge of the majority of them. For general dentists and restorative/ endodontic specialists were have been attend lectures regarding cavity sterilization, the percentages were (31.3%-32%) respectively. In contrast to fixed prosthodontist/ pedodontist group and the other specialties group present lower percentage of the lectures attendance (13.6%-13.5%) respectively. The possible explanation may be attributed to the following: for undergrad education this topic is covered briefly with lectures on cavity preparation for composite restoration and not as a separate topic.

The response of the participating dentists toward the fifth question, Are they effective against bacteria? The majority of respondents chose (yes); indicating they are aware about the effectiveness of cavity disinfectants and this reflect their high attitude towards the use of cavity disinfectants. The percentage range from (90.9%) for fixed prosthodontist /pedodontist, and (75.7%) for other specialists. The percentages of participating groups who thought they ineffective against bacteria either (0%) for fixed prosthodontist/ pedodontist, or low (4%-2.5%) for the rest of the groups.

Regarding the question "Do you use cavity disinfectants in your daily practice?" the results of the present study show there was no statistically significant difference between the groups (p-value >0.05%). The highest percentage of dentists who practice a cavity disinfection was the restorative/endodontic specialists (60%). This probably be attributed to their higher knowledge about the effect of remaining bacteria to the pulp. Furthermore, the cavity disinfection is a part of their syllabus which had an impact on their daily practice.

The last question in the current study's questionnaire is "Which of the following materials are you using as a cavity disinfectant?" there was no statistically significant difference between research groups regarding each material in the list. Furthermore, the result shows that the most commonly used materials by respondents are (CHX) followed by (NaOCl), which was in the same line to the previous studies [4, 25]. The least used material by respondents is (BAC) only (1 of 37) of other specialists has been use it; this is probably be contributed to low awareness to scientific name of the product. (BAC) usually comes in combination with other type of disinfectant like (EDTA). According to the results of current study Restorative/ endodontic specialists are more focusing on using four materials for cavity disinfection, with the following order CHX (56%), NaOCl (28%), normal saline (20%) phosphoric acid (4%) although the last two mentioned materials are not intended to use as cavity disinfectant; however, they help for cavity toileting before restoration.

Conclusion

Various systems and agents for disinfection are suggested. Understanding the disinfection mechanisms and their effects on the sealing ability of restorative material is essential in the selection of disinfection methods. Furthermore, undergrad education needs more focusing upon this important topic especially for specialties which deal with vital teeth such as restorative dentistry, endodontics, fixed prosthodontics, pedodontics.

Conflict of interest. Nil

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المستخلص

النهج المبتكر للتحكم في تسوس الأسنان يركز على الإزالة القصوى للبكتيريا من التسوس، مع تقليل فقدان نسيج الأسنان إلى أدنى حد. إستخدام مطهرات التجاويف يقلل بشكل فعال من عدد البكتيريا الباقية. تهدف الدراسة الحالية إلى تقييم ومقارنة المعرفة والمواقف والممارسات حول أنواع مختلفة من مطهرات التجاويف بين أطباء الأسنان العامين والمتخصصين الليبيين. تم إجراء دراسة مقطعية عبر الإنترنت شملت 151 طبيب أسنان في بنغازي (ليبيا) باستخدام استبيان مكون من 10 أسئلة. تم تحليل البيانات باستخدام اختبارات مربع كاي مع تحديد الدلالة الإحصائية عند $P< 0.05$ أظهرت النتائج أن كلورهكسيدين و هيبوكلوريت الصوديوم هما المطهران الأكثر شيوعًا. وكان هناك فرق ذو دلالة إحصائية في معرفة المجموعات المشاركة حول هيبوكلوريت الصوديوم ,ثنائي أمين الإيثيلين رباعي حمض الأسيتيك و بيروكسيد الهيدروجين. أشار أغلبية المشاركين إلى إستخدام مطهر التجاويف قبل الحفر الحمضي، وإعتقدوا أنه يمكن تطبيقه على التجاويف السطحية والعميقة. لم يحضر معظم المشاركين أي محاضرات بخصوص تطهير التجاويف، ومع ذلك، أبدوا موقفًا إيجابيًا إتجاه فعالية هذه المطهرات ضد البكتيريا. لم يكن هناك فرق ذو دلالة إحصائية بين المجموعات المشاركة حول الممارسة اليومية لإستخدام مطهرات التجاويف؛ كانت المطهرات الأكثر استخدامًا هي أن الكلورهكسيدين يليها هيبوكلوريت الصوديوم. إختيارالمطهر المناسب يتطلب فهم آليات التطهير وتأثيراتها على قوة ارتباط مادة الترميم.

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