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Assessment of the Endodontic Practices among General Dental Practitioners in Aden, Yemen

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ABSTRACT

Background: Maintaining the standard quality ensures the success of endodontic therapy.
Objective: The purpose of this study was to evaluate the endodontic practices currently used by general dental practitioners (GDPs) in Aden, Yemen, focusing on their awareness, attitudes, and clinical procedures.
Methods: Google Forms was used to create an anonymous English-language electronic questionnaire. There were thirty multiple-choice questions on the survey.
Results: A total of 385 GDPs were surveyed, achieving a response rate of 67.54% (n=260). The results indicated a predominance of female practitioners (59.2%), with a majority having 2-5 years of experience (61.5%). Most respondents (85.4%) performed root canal treatment (RCT) on all teeth, with 59.2% utilizing both single- and multiple-visit approaches. Only 13.8% of the respondents employed rubber dam isolation, highlighting a significant gap in adherence to recommended practices. The study found that 72.3% of practitioners determined working length using both radiographs and apex locators, and 64.6% utilized a combination of manual and rotary instrumentation for cleaning and shaping the canal. Approximately 60% of respondents reported not following up on their endodontic cases. Statistical analysis revealed significant associations between years of experience and various endodontic practices, including methods for testing pulp vitality, irrigation solutions, and obturation techniques used.
Conclusion: This study concluded that many of the GDPs adhered to the quality standard principles and had a positive attitude toward endodontic procedures. These findings point out the need for enhanced education and training to improve the quality of endodontic care provided by GDPs in Aden.

Keywords: Attitude; Endodontic; Knowledge; Procedures; Questionnaire; Techniques.

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INTRODUCTION

Eliminating infection and preventing root canal system reinfection are the main objectives of endodontic therapy. Therefore, for good consequences, stringent aseptic procedures and extremely technical measurements are required (1, 2). It is generally known that appropriate preparation of the access cavity, root canal system cleaning, shaping, disinfection (irrigation), and root canal system three-dimensional obturation are all necessary for successful endodontic therapy (3). Among these, irrigation is crucial to endodontic therapy. The only method for cleaning areas of the root canal wall that are untouched by mechanical cleaning and shaping is irrigation (4).

The precise determination and consistent maintenance of the working length during cleaning and shaping procedures are essential for successful endodontic outcomes (5). Effective cleaning, shaping, and obturation are difficult without accurate working length measurement (6). Therefore, the working length is a highly important factor in assessing the quality of endodontic treatment. Moreover, in the infection case of the root canal system, an intracanal interappointment medication that inhibits bacterial multiplication and restricts bacterial growth is recommended to be used (7).

Maintaining the standard quality ensures the success of endodontic treatment. Various studies have explored the knowledge and attitudes of general dental practitioners (GDPs) toward RCT procedures (8, 9). The attitudes and approaches of general dental practitioners and specialists and their skills and expertise all reflect the quality of root canal treatment performed in a country (10). However, studies have found that GDPs do not follow the treatment standards of endodontic treatment (11, 12). However, no such studies have been conducted in Yemen. Therefore, this study aimed to assess the awareness, attitudes, and clinical endodontic treatments performed by GDPs in Aden, Yemen.

METHODS

Study Design and Population

This was a cross-sectional study. By using an online sample size calculator (https://www.calculator.net/sample-size-calculator.html?type=1&cl=95&ci=5&app=50&ps=&x=Calculate), the estimated sample size, calculated at a 95% confidence level with a 5% margin of error, was 385. Therefore, GDPs (n=385) in Aden, Yemen, were administered an electronic questionnaire. However, some participants were excluded due to incomplete information. The title of the project and its goals were included in the e-questionnaire. All participants confirmed that their responses were accurate to the best of their knowledge and considered how they conducted their dental practice on a daily basis.

Ethical Considerations

The use of data for research and educational purposes was approved by the participants. The medical research ethics committee of the Faculty of Medicine and Health Sciences, University of Science and Technology, Aden, granted ethical approval for this study (MEC/AD0129).

Data Collection Tool

A questionnaire was created based on previously published GDP surveys (13, 14, 15). Google Forms was used to create an anonymous English-language electronic questionnaire. The questionnaire contained 30 multiple-choice questions. The questionnaire consisted of two sections: All survey participants were asked to provide demographic information on gender, years of experience (2-5 years, 6-10 years, 11-15 years, and >15 years), and place of employment (government or private), which were included in the first section. The remaining 27 questions in the questionnaire, which made up the second section, aimed to evaluate general dental practitioners' (GDPs) knowledge, attitudes, and clinical practices of GDPs concerning adherence to established endodontic treatment standards in the clinic. All responses were anonymized.

Statistical Analysis

IBM SPSS Version 27 was used to analyze the collected data. Frequencies and percentages were used in descriptive statistical analysis, along with the chi-square and Pearson chi-square tests. The level of significance was set at $P < 0.05$.

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RESULTS

Of the 385 questionnaires distributed, 270 participants responded. However, 10 participants were excluded due to incomplete information, achieving 260 (67.54%) responses. The findings of the current survey are summarized as follows:

With regard to gender, 59.2% were female, while 40.8% were male. The chi-square test showed a statistically significant difference between the genders (P 0.003). The years of experience of the respondents with working experience of 2-5 years were 61.5%; 6-10 years, 25.4%; 11-15 years, 4.6%; and the remaining with more than 15 years, 8.5%. There was a statistically significant difference (P < 0.001) between the working experience groups. The majority of the respondents (69.2%) worked in private clinics, and 30.8% worked in government health care practices. Table 1 indicated that there was a statistically significant difference (P < 0.001).

Table 1: Demographic details of study participants, (n=260)

Demographic Variables		Number	Percentage	P value (Chi-square test)
Gender	Male	106	40.8	0.003*
	Female	154	59.2	
Years of experience	2-5 years	160	61.5	0.001*
	6-10 years	66	25.4	
	11-15 years	12	4.6	
	More than 15 years	22	8.5	
Workplace	Government	80	30.8	0.001*
	Private	180	69.2	

*The p value less than 0.05 means significant difference.

Based on the information indicating which types of teeth practitioners had treated with RCT, almost all respondents (85.4%) performed RCT on all teeth, whereas 8.5% treated anterior and premolar teeth, 4.6% treated molar teeth only, and 1.5% treated anterior teeth only. To assess pulp vitality, many respondents (43.8%) used hot, cold, and electric pulp tests, whereas 17.7% did not use any pulp tests and depended on the history, clinical examinations, and periapical radiographs. An RCT was conducted in both single and multiple visits by more than half of the respondents (59.2%). In the case of multiple visits, intracanal medicaments were used by 47.7% of the respondents, whereas 8.5% did not use them. In addition, 58.9% of the respondents preferred to use calcium hydroxide paste as an intracanal medicament between visits. Most respondents (75.4%) used analgesics to treat flare-ups between endodontic appointments, while 10.8% referred to specialists. Rubber dam isolation was used by 13.8% of the respondents, and 60% did not use a rubber dam in all their cases during endodontic treatment; however, they believed that isolation using a cotton roll was sufficient. For access cavity preparation, most respondents (73.8%) preferred to use a round bur, while 12.3% used a straight fissure bur, and 6.9% used a tapered bur. However, the remainder of the respondents (6.9%) used a combination of either a round, straight fissure, or tapered bur with the Endo Z bur. In addition, 82.3% of the respondents used a visual method, 40% used DG-16 Explorer, 13.1% used magnification, 16.2% used Cone-beam computed tomography (CBCT), and 1.5% used dyes to locate the canals. Of all respondents, 43.8% preferred using barbed broaches to remove the pulp tissue, whereas 29.2% preferred K-files. For determining working length, radiographic examination was most frequently combined with an electronic apex locator. Many respondents (72.3%) employed both strategies. A total of 64.6% of respondents reported they used both manual and rotary instruments to complete the cleaning and shaping procedures. The standardized technique was used by 41.5% of respondents, the crown-down technique by 30.8%, and the step-back technique by 26.2%. To maintain the apical foramen patent, most respondents (54.6%) used patency files. A 39.2% of the respondents used sodium hypochlorite and EDTA as their irrigation solution of choice, with 33.8% using sodium hypochlorite only and 24.6% reporting using sodium hypochlorite, EDTA, and chlorhexidine. However, 80.6% of the respondents used normal saline between the various irrigants. A syringe with a side-ended needle was used by 68.5% of the respondents,

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while 25.4% used a syringe with a regular needle. In the case of acute apical abscess, most participants (57.7%) avoided leaving the tooth open in the infected canals, but 20.8% left it open. 55.4% of respondents selected the cold lateral condensation obturation technique, while 26.9% preferred to use a single cone technique and 17.7% preferred to use the warm vertical condensation technique. The average percentage of participants who decided to cut gutta-percha at the orifice level was 80.8%, while 13.1% wanted to cut below the orifice. A zinc oxide eugenol sealer was chosen by 73.8% of respondents, a calcium hydroxide-based sealer by 6.2%, and a resin-based root canal sealer by 18.5%. The remaining 16.9% of the respondents used MTA-based sealers. Of the respondents, 40.8% preferred immediate coronal restoration after obturation, whereas 45.4% preferred to wait one week.

After root canal obturation, composite was used as the final restoration by 43.8% of the respondents, followed by 41.5% using glass ionomer and 14.7% using other materials such as polycarboxylate cement or mineral trioxide aggregate (MTA). A total of 28.5% of respondents performed occlusal reduction, whereas 36.2% of respondents reported no occlusal reduction, and 35.4% of respondents performed it occasionally. After the completion of RCT, 53.8% of practitioners recommended a crown or bridge as an additional coronal restoration, while 40% of practitioners advised it on occasion. Whenever endodontic mishaps occurred, 38.5% of respondents informed the patient and continued the treatment, while some respondents (30%) would not inform the patient and continue the treatment. However, 21.5% of the respondents stopped treating the patient and referred them to the endodontist for further care. Interestingly, many respondents (60%) did not follow up on their endodontic cases, as shown in Table 2.

Table 2: Variety of materials and instruments used throughout the root canal treatment (RCT), (n=260)

Variety of materials and instruments used throughout RCT		Number	Percentage
1. **What type of teeth do you treat by root canal treatment (RCT)?**	Anterior only	4	1.5
	Anterior and premolars	22	8.5
	Molars	12	4.6
	All teeth	222	85.4
2. **How do you assess the vitality of pulp to make your diagnosis?**	Heat test	54	20.8
	Cold test	34	13.1
	Electric pulp testing	12	4.6
	Combination of above	114	43.8
	Other:	46	17.7
3. **How many visits are RCT performed?**	Single visit treatment	6	2.3
	Multiple visit treatment	100	38.5
	Both	154	59.2
4. **Do you use intracanal medicament in case of multiple visit endodontic treatment?**	Yes	124	47.7
	No	22	8.5
	Occasionally	114	43.8
5. What is the type of the intracanal medicament do you use?	Zinc oxide eugenol	34	13.1
	Formocresol	36	13.8
	Calcium hydroxide paste	154	59.2
	Corticosteroid–Antibiotic Combinations	16	6.2
	Other	20	7.7
6. **How are flare-ups managed between appointments?**	Occlusal reduction	70	26.9
	Antibiotic	44	16.9
	Intra canal medicament	24	9.2
	Analgesic	94	36.2

		Refer to the Specialist	28	10.8
7.	**Are rubber dams used for isolation?**	Yes	36	13.8
		No	156	60.0
		Occasionally	68	26.2
8.	**When preparing an access cavity, which bur do you prefer?**	Round	192	73.8
		Straight fissure	32	12.3
		Tapered bur	18	6.9
		Others:	18	6.9
9.	**Which method do you use to locate the canal?**	Visual only	122	46.9
		DG-16 explorer	24	9.2
		Magnification Dyes	8	3.1
		CBCT	14	5.4
		Combination of the above	92	35.4
10.	**What instrument is used to extirpate the pulp?**	Barbed broach	114	43.8
		K-file	76	29.2
		H-file	14	5.4
		Rotary files	56	21.5
11.	**How do you determine the tooth's working length?**	Conventional Radiograph only	40	15.4
		Apex locator only	28	10.8
		Both	188	72.3
		None	4	1.5
12.	**Which instrumentation do you use for the cleaning and shaping?**	Manual instrumentation	52	20.0
		Rotary instrumentation	40	15.4
		Both	168	64.6
13.	**What technique do you use for shaping and cleaning?**	Step-back technique	68	26.2
		Crown down technique	80	30.8
		Hybrid technique	4	1.5
		Standardized technique	108	41.5
14.	**Do you keep apical foramen patent by using patency file?**	Yes	142	54.6
		No	28	10.8
		Occasionally	90	34.6
15.	**What type of irrigation do you use?**	Sodium hypochlorite	88	33.8
		EDTA	0	0.0
		Chlorhexidine	6	2.3
		Combination of above	64	24.6
		Sodium hypochlorite + EDTA	102	39.2
16.	**Do you use a normal saline between the irrigation solutions?**	Yes	210	80.8
		No	26	10.0
		Occasionally	24	9.2
17.	**What type of irrigation technique do you use?**	Syringe with a regular needle	66	25.4
		Syringe with a side vented needle	178	68.5
		Activation devices	16	6.2
18.	**Do you leave the tooth open in infected canals (if there is abscess)?**	Yes	54	20.8
		No	150	57.7
		Occasionally	56	21.5
19.	**What method of obturation do you use?**	Cold Lateral condensation	144	55.4
		Single cone	70	26.9

	Warm Vertical condensation	46	17.7
20. **At what coronal level do you prefer to cut the gutta-percha**	At the orifice level	210	80.8
	Below the orifice	34	13.1
	To the pulp chamber level	16	6.2
21. **What type of sealer do you use?**	Resin-based sealer	40	15.4
	Zinc oxide eugenol sealer	182	70.0
	Calcium Hydroxide-based sealer	12	4.6
	MTA-based sealer	26	10.0
22. **What material of coronal restoration do you use after the obturation?**	Composite	114	43.8
	Glass ionomer	108	41.5
	Others	38	14.6
23. **When do you perform coronal restoration after obturation?**	Immediately	106	40.8
	Within one week	118	45.4
	Within two weeks	22	8.5
	More than two weeks	14	5.4
24. **Do you perform occlusal reduction after RCT?**	Yes	74	28.5
	No	94	36.2
	Occasionally	92	35.4
25. **Do you advise the patients to get a crown after RCT?**	Yes	140	53.8
	No	16	6.2
	Occasionally	104	40.0
26. **What would you do if an endodontic mishap happened?**	Inform the patient	24	9.2
	Would not inform the patient	2	0.8
	Would inform the patient and continue the treatment	100	38.5
	Would not inform the patient and continue the treatment	78	30.0
	Refer to endodontist	56	21.5
27. **Do you follow up on your RCT cases?**	No	156	60.0
	Yes, after every 3 months	52	20.0
	Yes, after every 6 months	44	16.9
	Yes, after every 1 year	8	3.1

Data analysis showed that practitioners' years of experience were associated with many areas of endodontic practice using the Pearson chi-square test (Table 3). Years of experience were affected by practitioners' gender (p 0.005); however, most practitioners were female. A significant effect was reported in the use of varied pulp vitality testing methods (p 0.001) and in different approaches to managing inter-appointment flare-ups (p 0.003). In addition, it has been shown that the method used to locate the canal (p 0.002) and pulp extirpation method (p 0.030) are significantly influenced by practitioners' years of experience; however, it is reported that the large majority of practitioners with less than five years of experience used only visual methods to locate the canal.

The method used for working length measurement was significantly associated with the practitioners' years of experience ($p < 0.001$) and the use of different instruments for canal cleaning and shaping (p 0.042). Regarding irrigation, a great variation between practitioners was observed; the use of normal saline as one of the irrigation solutions ($p < 0.001$) and the irrigation methods used ($p = 0.028$) were significantly influenced by practitioners' years of experience.

In cases of abscesses, the decision to leave the tooth open during root canal treatment was affected by the practitioner's experience ($p = 0.010$). The methods of

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root canal obturation, including the technique used and the type of sealer, also showed a very strong association with experience ($p < 0.001$) for both. The timing of coronal restoration (p 0.022) and choice of restorative material (p 0.010) after completion of obturation were significantly influenced by the practitioners' years of experience (Table 3).

Table 3: Association of endodontic practices with respect to practitioners' years of experience, (n=260)

Variables		Years of experience				
		2-5 years	6-10 years	11-15 years	More than 15 years	P value
Gender	Male	74	16	8	8	0.005*
	Female	86	50	4	14	
Total		160	66	12	22	
Workplace	Government	58	14	4	4	0.080
	Private	102	52	8	18	
Total		160	66	12	22	
What type of teeth do you treat by root canal treatment (RCT)?	Anterior	2	0	0	2	0.025*
	Anterior and premolars	16	6	0	0	
	Molar	10	0	0	2	
	All teeth	132	60	12	18	
Total		160	66	12	22	
How do you assess the vitality of pulp to make your diagnosis?	Hot test	40	12	0	2	<0.001*
	Cold test	24	8	0	2	
	Electric pulp testing	10	0	2	0	
	Combination of above	60	28	10	16	
	Other	26	18	0	2	
Total		160	66	12	22	
How many visits are RCT performed?	Single visit treatment	6	0	0	0	0.376
	Multiple visit treatment	66	24	4	6	
	Both	88	42	8	16	
Total		160	66	12	22	
Do you use intracanal medicament in case of multiple visit endodontic treatment?	Yes	72	34	8	10	0.510
	No	12	8	0	2	
	Occasionally	76	24	4	10	
Total		160	66	12	22	
What is the type of the intracanal medicament do you use?	Zinc oxide eugenol	22	10	0	2	0.116
	Formocresol	30	4	0	2	
	Calcium hydroxide paste	92	38	10	14	
	Corticosteroid-Antibiotic Combinations	8	6	0	2	
	Other	8	8	2	2	
Total		160	66	12	22	
How are flare-ups managed between appointments?	Occlusal reduction	34	24	6	6	0.003*
	Antibiotic	22	10	4	8	
	Intra canal medicament	18	6	0	0	
	Analgesic	70	20	0	4	
	Refer to the Specialist	16	6	2	4	
Total		160	66	12	22	
Are rubber dams used for isolation?	Yes	24	6	2	4	0.629
	No	96	44	6	10	
	Occasionally	40	16	4	8	
Total		160	66	12	22	
When preparing an access cavity, which bur do you prefer?	Round	118	48	8	18	0.788
	Straight fissure	20	8	2	2	
	Tapered bur	10	6	0	2	
	Others	12	4	2	0	

Total		160	66	12	22	
Which method do you use to locate the canal?	Visual only	84	30	2	6	0.002*
	DG-16 explorer	18	4	0	2	
	Magnification Dyes	4	4	0	0	
	CBCT Magnification	4	6	0	4	
	Combination of above	50	22	10	10	
Total		160	66	12	22	
What instrument is used to extirpate the pulp?	Barbed broach	70	28	6	10	0.030*
	K-file	50	22	2	2	
	H-file	8	0	2	4	
	Rotary files	32	16	2	6	
Total		160	66	12	22	
How do you determine the tooth's working length?	Conventional Radiograph only	28	12	0	0	<0.001*
	Apex locator only	20	6	2	0	
	Both	112	46	8	22	
	None	0	2	2	0	
Total		160	66	12	22	
Which instrumentation do you use for the cleaning and shaping?	Manual instrumentation	40	10	2	0	0.042*
	Rotary instrumentation	28	6	2	4	
	Both	92	50	8	18	
Total		160	66	12	22	
What technique do you use for shaping and cleaning?	Step-back technique	36	24	2	6	0.481
	Crown down technique	48	20	4	8	
	Hybrid technique	4	0	0	0	
	Standardized technique	72	22	6	8	
Total		160	66	12	22	
Do you keep apical foramen patent by using patency file?	Yes	86	40	4	12	0.087
	No	20	8	0	0	
	Occasionally	54	18	8	10	
Total		160	66	12	22	
What type of irrigation do you use?	Sodium hypochlorite	54	18	6	10	0.089
	Chlorhexidine	2	4	0	0	
	Combination of above	38	14	4	8	
	Sodium hypochlorite + EDTA	66	30	2	4	
Total		160	66	12	22	
Do you use a normal saline between the irrigation solutions?	Yes	142	46	10	12	<0.001*
	No	8	10	2	6	
	Occasionally	10	10	0	4	
Total		160	66	12	22	
What type of irrigation technique do you use?	Syringe with a regular needle	34	22	4	6	0.028*
	Syringe with a side vented needle	120	38	8	12	
	Activation devices	6	6	0	4	
Total		160	66	12	22	
Do you leave the tooth open in infected canals (if there is abscess)?	Yes	24	16	6	8	0.010*
	No	102	32	6	10	
	Occasionally	34	18	0	4	
Total		160	66	12	22	
What method of obturation do you use?	Cold Lateral compaction	86	44	10	4	<0.001*
	Single cone	44	16	2	8	

	Warm Vertical compaction	30	6	0	10	
Total		160	66	12	22	
At what coronal level do you prefer to cut the gutta-percha	At the orifice level	128	54	10	18	0.955
	Below the orifice	22	8	2	2	
	To the pulp chamber level	10	4	0	2	
Total		160	66	12	22	
What type of sealer do you use?	Resin-based sealer	18	14	6	2	<0.001*
	Zinc oxide eugenol sealer	124	40	6	12	
	Calcium Hydroxide-based sealer	6	2	0	4	
	MTA-based sealer	12	10	0	4	
Total		160	66	12	22	
When do you perform coronal restoration after obturation?	Immediately	66	28	4	8	0.022*
	Within one week	74	28	6	10	
	Within two weeks	18	2	0	2	
	More than two weeks	2	8	2	2	
Total		160	66	12	22	
What material of coronal restoration do you use after the obturation?	Composite	24	16	6	8	0.010*
	Glass ionomer	102	32	6	10	
	Others	34	18	0	4	
Total		160	66	12	22	
Do you perform occlusal reduction after RCT?	Yes	48	16	4	6	0.054
	No	62	16	6	10	
	Occasionally	50	34	2	6	
Total		160	66	12	22	
Do you advise the patients to get a crown after RCT?	Yes	82	42	6	10	0.184
	No	12	2	2	0	
	Occasionally	66	22	4	12	
Total		160	66	12	22	
What would you do if an endodontic mishap happened?	Inform the patient	14	4	2	4	0.024*
	Would not inform the patient	2	0	0	0	
	Would inform the patient and continue the treatment	66	22	4	8	
	Would not inform the patient and continue the treatment	42	32	2	2	
	Refer to endodontist	36	8	4	8	
Total		160	66	12	22	
Do you follow up on your RCT cases?	No	98	36	8	14	0.177
	yes, after every 3 months	32	12	2	6	
	yes, after every 6 months	28	12	2	2	
	yes, after every 1 year	2	6	0	0	
Total		160	66	12	22	

*The p value less than 0.05 means significant difference.

DISCUSSION

The survey questionnaire is a tool that is frequently used to assess healthcare systems and provides information about the opinions, attitudes, and behavior of respondents (16). Although low response rates in postal surveys are common (17, 18), the current survey had a 67.54% response rate. With these limitations, the findings of the current study provide information about the instruments, materials, strategies, and techniques used by the GDPs in Aden, Yemen, towards endodontic standards. Most practitioners performed root canal treatment on all teeth. However, based on years of experience, some GDPs with 2-5 years of experience performed root canal treatment only in the anterior and

premolar teeth. This may be because their confidence in the knowledge and skills of RCT procedures decreased as years of experience did. The results of this study are in agreement with those of Bulmer and Currell (19).

To determine the correct endodontic treatment, a precise diagnosis of the pulp state is crucial. The recorded dental history, clinical examination data, vital pulp testing, and radiographic findings all contribute to the accuracy of pulp diagnosis. The clinician's experience in the field also affects the diagnosis procedure to some extent (20). A common pulp testing procedure is to first apply an electric pulp test, followed by thermal tests (cold and heat) (21). The result of the current study was slightly in accordance with the study performed by Patro and Meto (21) where 43.8% of the respondents determined the pulp status by applying a combination of electric pulp tests and thermal tests (cold and heat) to get an accurate pulp diagnosis.

According to US research, single-visit endodontics is becoming more popular, particularly in situations when apical periodontitis is absent (22). However, some dentists choose to treat patients through multiple visits. They could postpone obturating the root canal until both the pain and other symptoms have subsided (18, 23). In the current study, multiple visits were favored over a single visit by 38.5% of respondents, while 59.2% of respondents treated the patients using both single and multiple visits. The choice of multiple visits could be attributed to the lack of experience and clinical skills of some practitioners, which are necessary to complete endodontic therapy in a single visit. This result was slightly in agreement with the study performed by Jouhar, Ahmed (13), who reported that 64.7% of the respondents performed root canal treatment in both single and multiple visits. Another study showed that multiple visits were preferred over a single visit by 60.9% of respondents in the main working place and 70.1% of respondents in the private practice (18). A study performed by Schwendicke and Göstemeyer (24) concluded that there is not enough data to determine if single-visit or multiple-visit RCT produces significantly different results. A cautious approach could be to favor multiple-visit therapy for teeth where the risk of complications is elevated, such as teeth with pre-existing periapical lesions, due to the potential elevated risk of flare-up (24).

The main goal of intracanal treatment is to remove the toxins and bacteria from the root canal system. These antibacterial and disinfecting chemical agents are placed inside the root canal to directly inhibit or eliminate microorganisms, neutralize toxins, adjust the pH of the surrounding environment, and provide biological conditions favorable to periapical tissue regeneration and repair (25, 26). In the current study, 47.7% of respondents used intracanal medicaments during multiple visits. The calcium hydroxide paste was the most used intracanal medicament by 59.7% of respondents. Because of its alkalinity and antibacterial qualities, calcium hydroxide is considered one of the most effective intracanal medications in endodontic therapy (27).

A rubber dam is advised for isolation, improved access visibility, and to protect the patient from aspiration or inhalation of instruments during endodontic treatment (13, 18, 28). The results of the present study demonstrated that only 13.8% of dental practitioners used a rubber dam, while 60% did not use it, which was unacceptable. This finding is somewhat in line with research done in Nepal, where 10.97% of GDPs used a rubber dam compared to 88.02% who never did (29). Lack of education, insufficient skills, extra costs, and extra time are possible justifications for not utilizing a rubber dam. Thus, education must be prioritized in order to increase knowledge of the importance of rubber dams in daily practice and to encourage their use (29).

One of the crucial formal steps to obtain the highest effective cleansing and disinfection of the root canal system is accurate working length measurement (30). The present study reported that 72.3% of the respondents determined working length by using both a radiograph and an apex locator. This study is consistent with research conducted by Jouhar, Ahmed (13). Another study has been conducted in Sri Lanka that reported that, to determine the working length, most of the respondents relied on tactile sensation (18). Since each radiographic or electronic apex locator approach has unique advantages that increase the success of endodontic treatment and provide patients with better, more comprehensive care, it is best to utilize a combination of radiographic and electronic apex locators (31).

To ensure that the root canal treatment is effective, the canal's cleaning and shaping are delicate steps that must be completed precisely (29). According to the current study, 64.6% of respondents cleaned and shaped the root canal systems using a combination of manual and rotary instrumentation procedures. This finding was in agreement with a study performed by Jouhar, Ahmed (13), who indicated that 63.8% of the respondents preferred both manual and rotary instrumentations. Due to the advantages of each technique, a thorough root canal preparation of the root canal system may be accomplished by using both manual and rotary instrumentation techniques, which lead to an increased endodontic treatment success rate (28). As mentioned previously, in the present study, both manual and rotary instrumentation techniques have been used for the cleaning and shaping of the root canal system. Thus, the standardized technique, with 54% of the respondents, followed by the crown-down technique (40%), were the two most used techniques among respondents for root canal preparation. The Mtwo rotary instrument system uses an established technique described as the single-length technique, where all instruments in the sequence are brought to full working length from beginning to end of the procedure (32). However, the crown-down technique was used with the most recent rotary instrumentation (33). Another study reported that the step-back technique was the most common technique for canal preparation among Sri Lankan respondents. This could be the result because the practitioners are preparing the root canal system manually rather than using the modern engine-driven techniques (18).

During the preparation of the root canal, dentin and apical pulp tissue debris tend to be compacted into the apical foramen, which may cause apical blockage and interfere with the working length. The repeated passing of a small file (patency file) through the apical foramen during root canal preparation prevents the accumulation of debris in this area and leaves the foramen unblocked (patent). This concept has been defined as apical foramen patency (34). The present study revealed that 54.6% of the respondents used a patency file to keep the foramen patent, while 34.6% used it occasionally. These findings were nearby to the study by Jouhar, Ahmed (13), who reported that 60.6% of the respondents used patency files to keep the apical foramen patent, while 26.9% used it on occasion. Thus, the relevance of patency files during endodontic treatment should be highlighted for GDPs.

Besides mechanical preparation, the root canal system should be irrigated because of accessory canals and the existence of microbes. Sodium hypochlorite (NaOCl) has been demonstrated to be the recommended root canal irrigant due to its potent antibacterial and tissue-dissolving properties (2). Such an opinion was shared by the majority of the respondents in studies performed by Malmberg and Hägg (2) and Bandaranayake and Wettasinghe (18), which revealed that sodium hypochlorite was the most common irrigant used during the cleaning and shaping procedure. These findings were slightly in accordance with the result of the present study, which demonstrated that only 33.8% of the respondents used sodium hypochlorite; however, sodium hypochlorite alone was the second-rated option after sodium hypochlorite + EDTA (39.2%). A study performed by Mehta and Raisingani (35) showed that the most frequently used irrigants were sodium hypochlorite (52%) and normal saline solutions (24.66%). Another study revealed that sodium hypochlorite (63.8%), followed by normal saline, are the most common irrigants used (13). A study by Shrestha and Dahal (36) showed that both normal saline and sodium hypochlorite were preferred by 91% of the respondents, followed by hydrogen peroxide (46%). Regarding the normal saline, our study endorsed the above-mentioned study and showed that most of the respondents (80.8%) used normal saline as an adjunct to chemical irrigant. In the present study, syringe irrigation with a side-vented needle has been shown to be the irrigation technique to deliver the irrigants by the majority of the respondents (68.5%). A systematic review study evaluated the effect of various parameters on irrigant flow and apical pressure using manual syringe needle irrigation and concluded that syringe irrigation with a side-vented needle proved better than syringe irrigation with an open-ended needle (37).

Cold lateral compaction of gutta-percha with a root canal sealer is widely accepted and the most prevalent obturation procedure (8, 38). Root canal sealers are used to fill irregular root canal areas that gutta-percha cannot, as well as to encapsulate any remaining microorganisms and limit their growth (39). In the present study, the cold lateral compaction technique and zinc oxide eugenol sealer have been used by the

majority of the respondents (55.4% and 70%, respectively). These findings were endorsed to some extent by another study in which 95.12% of GDPs used the lateral compaction technique, and 75.6% used zinc oxide eugenol as a root canal sealer (29).

To improve the success of root canal treatment, the canals should be well cleaned and shaped, and the quality of both root canal filling and coronal restoration are important as well (40). In an 8-year retrospective study, the survival of endodontically treated teeth based on the timing of the final coronal restoration was analyzed and found that when coronal restoration had been done from 0 to 14 days, the survival rate of teeth was 72%; however, from 15 to 59 days, it was 51%, and 39% after 60+ days (41). Therefore, the earlier the final coronal restoration is placed, the higher the survival rate. The result of the present study showed that 40.8% of the respondents were performing coronal restoration immediately and 45.4% within one week. This result was in accordance with previous studies (41, 42), where the majority of respondents had performed coronal restorations during the first week after completion of root canal obturation. Following the completion of endodontic treatment, patient management should not be considered complete until the tooth has been properly restored to both the shape and function (43). An ideal coronal restoration should prevent recontamination of the root canal system and/or periapical area, restore esthetics and function, and protect the endodontically treated teeth (44, 45). In the term of microleakage, a recent study demonstrated that there was no significant difference between composite and glass ionomer, and both of them can be used as post-endodontic restoration (46). In the present study, composite and glass ionomer were the most used materials as final coronal restoration after root canal obturation, by 43.8% and 41.5% of respondents, respectively.

Stimulation of nociceptors is the cause of pain while chewing or percussion. Pain is decreased by reducing the occlusal surfaces because this minimizes the nociceptors' mechanical sensitivity (47). In the present study, 28.5% of respondents performed occlusal reduction after the RCT, whereas 36.2% did not, and 35.4% did it on occasion. Another study presented that teeth with an acute apical periodontitis showed less discomfort following occlusal reduction after RCT. It was recommended that patients undergoing endodontic treatment need occlusal reduction as an additional pain-relief method (48). However, several investigators evaluated the effect of occlusal reduction on postoperative pain levels after RCT and have suggested that occlusal reduction has no influence on postoperative pain levels (49, 50, 51).

Generally, the best advocated restorative option for an endodontically treated tooth is frequently a prosthetic crown (52, 53). It has been shown that teeth restored with indirect restorations within 6 months of the root filling had higher long-term survival rates than those restored with direct restorations during the first five to six years following RCT (53). According to previous information, it seems good that 53.8% of respondents in this survey advised patients to have a prosthetic crown following RCT to save their teeth, and 40% of respondents did it occasionally. The restoration of the tooth is one aspect that has been mostly examined among all the pre-, peri-, and postoperative aspects associated with RCT. Although a number of studies suggest that teeth with root fillings and indirect restorations have a better survival rate than those with direct restorations, it is impossible to determine if this is a prognostic indicator of outcome (54).

In the present study, when endodontic mishaps occurred, it was reported that 38.5% of the respondents informed the patient and continued the treatment, while 30% did not inform the patient and continued the treatment, and 21.5% referred the patient to an endodontist. Endodontic mishaps are unpleasant procedural accidents that happen during endodontic treatment, which can be a result of an iatrogenic mistake or due to lack of knowledge (55), which may lower the quality of treatment and may have harmful effects on patients' health (56). When a procedural accident occurs, inform the patient about the nature of the procedure accident, how it may be fixed, and how it can affect the tooth's prognosis and the plan of treatment as a whole. Dentists should refer a patient to a specialist if a procedural mishap results in a situation that is beyond their training and expertise.

Post-operative follow-ups are essential following RCT for the dentist to gain information about their performance or identify any areas of weakness that might need revising in their treatment plans (57). Accordingly, post-operative follow-ups are also

beneficial to the patient in monitoring the healing process and ensuring the long-term success of the treatment. As recommended by the European Society of Endodontology, the root canal treatment should be evaluated for a minimal period of one year and then subsequently as needed where healing is incomplete or there is a history of trauma (10). In the present study, GDPs report different opinions, where the majority of the respondents (60%) did not have a set for follow-ups for their cases, 20% did it every 3 months, 16.9% every 6 months, and 3.1% after every 1 year. This is in line with other studies that have found post-operative follow-ups after endodontic treatment to be infrequently performed (57, 58). If the GDPs consider a patient's lack of symptoms to be a satisfactory treatment outcome, the idea that follow-ups are crucial for feedback may not be well supported, which should be retaught and emphasized while teaching students in college.

CONCLUSION

Despite the study's limitations, it is concluded that the majority of general dental practitioners adhered to the quality standard guiding principles and had a favorable attitude toward endodontic procedures. The majority of endodontic procedures showed significant associations with the practitioner's years of experience, regardless of gender. Furthermore, it is advised that dentists employ continuing dental education programs to further improve their knowledge and practices with contemporary techniques and materials.

The results of this study should serve as a baseline for future research in Yemen and other countries, with a larger age range that includes more experienced dentists. Future research should also focus on knowing contemporary methods used in clinical endodontics.

Authors' Contributions

Nashwan A. Al-Afifi contributed to manuscript writing. Sana Aghbari performed data analysis. Samah Al-Amery conducted data review. All authors participated in data interpretation, supervised the study, contributed to critical discussion of the results, and reviewed and approved the final version of the manuscript.

Data Preservation & Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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Conflict of Interest

The authors declare that there is no conflict of interest in this work.

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