Saudi Dental Journal (2020) 32, 213–218

King Saud University

Saudi Dental Journal

www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

Knowledge and practices of decontamination during root canal treatment by dentists in Jeddah

Maysoon Haji Albahiti

Department of Endodontics, Faculty of Dentistry, King Abdulaziz University, Saudi Arabia

Received 8 April 2019; revised 27 August 2019; accepted 29 August 2019
Available online 6 September 2019

KEYWORDS

Knowledge;
Practices;
Microbial infection;
Root canal treatment;
Jeddah;
Mechanical irrigation devices

Abstract *Background:* The periapical area is healed through disinfection of root canal system and reduction of microbial infection after root canal.

Purpose: To assess the knowledge of dental practitioners about decontamination during root canal treatment and the techniques used in the government and private sectors of Jeddah, Saudi Arabia.

Methods: 103 dental practitioners and interns from private and governmental sectors performing root canal treatment were included. To extract information, a questionnaire assessing knowledge and preferred techniques used in decontamination during root canals treatment was distributed. The association of variables was investigated using chi-square tests.

Results: The findings reflected that 82.5% of subjects used rubber dam for isolation with significantly more practitioner in the governmental (95.2%) as compared to the private sector (27.8%). Chelating agents were used by 13.3% of the practitioners in government sector and 1% practitioners in private sector (1%). The most commonly used irrigant was sodium hypochlorite. Calcium hydroxide was used more frequently in the governmental sector (29.8%) than in the private sector (11.8%), as intracanal medicament. Mechanical irrigation devices were used by 2.4% of practitioners in the governmental sector only.

Conclusions: There is a significant difference in practicing root canal disinfection techniques among dentists in governmental and private sectors but no difference in degree of knowledge.

1. Introduction

Endodontic treatment prevents the development of microbial infection, as it involves successful entrance, cleaning, shaping, and obturation of root canal system. Periapical healing is carried out by the adjacent periodontium, once the microbial insult within the tooth has been controlled (Panuganti et al., 2016). All steps involved in the endodontic treatment are responsible for minimizing and eliminating the microbial contamination, following the aseptic sequence (Haapasalo et al.,

E-mail address: mhaji@kau.edu.sa
Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.sdentj.2019.08.010
1013-9052

2005). Mechanical cleaning and shaping of the root canal result in removal of bacteria and debris. This is opened up and disinfected by using the chemical antibacterial and chelating agents. The long-term success of endodontic treatment depends on complete debridement and disinfection of pulpal space. However, the irregularities of root canal systems depend on residual pulpal tissue, dentin debris, and bacteria, even after meticulous mechanical preparation (Gomes et al., 2013).

The use of rubber dam provides significant patient production, clean operating field, retraction and protection of soft tissues, and improved access and visibility; therefore, it is considered as standard care provided during the root canal treatment (Hulsmann, 2016). Rubber dam is capable of protecting from aspiration of operative materials. It is also responsible for minimizing the contamination of accessed root canal space from oropharyngeal micro-organisms, either in aerosolized or in saliva. The absence of rubber dam is associated with poorer outcomes as the ability to disinfect the canal space is compromised (Kulild, 2013).

The treatment outcome is determined on the basis of disinfectant agents used during root canal treatment (Unal et al., 2012). The irrigating solutions possess a broad antimicrobial spectrum and high efficacy against anaerobic and facultative microorganisms organized in inactivate endotoxin, biofilms, and dissolve necrotic pulp tissue remnants. Endodontic irrigants coming in contact with the vital tissues need to be non-toxic, non-caustic to periodontal tissues, and also have decreased ability to cause anaphylactic reaction. Sodium Hypochlorite (NaOCl) is among the most effective irrigants for eliminating microbes. Its antibacterial effectiveness is a function of concentration and contact time (Baumgartner et al., 2007). The endodontic instrumentation produces a smear layer that is potentially contaminated and it delays or inhibits the penetration of microbial agents. This smear layer and superficial debris from the surfaces of instrumented root canals are effectively removed by flushing of the root canals with the chelating agent known as ethylenediaminetetraacetic acid (EDTA) (Baumgartner et al., 2007).

Aqueous solution of 2% chlorhexidine gluconate is sometimes used to irrigate the root canals as it has a high kill rate against E. faecalis (Basrani, 2011). Chlorhexidine is unable to dissolve necrotic tissue remnants and is more effective on Gram-positive bacteria, as compared to Gram-negative bacteria. It cannot be advocated as the main irrigant in standard endodontic cases. Zehnder (2006) conducted a randomized clinical trial to show that 0.2% chlorhexidine was less efficient as compared to 2.5% hypochlorite to obtain negative cultures (Zehnder, 2006). Therefore, chlorhexidine will be more efficacious if used after the NaOCl has dissolved as much tissue as possible (Basrani, 2011). However, it is not essential to use these two solutions consecutively in the same setting as their chemical interaction produces a toxic percipitate (Basrani, 2011).

The eradication of microorganisms from root canal is achieved by using $Ca(OH)_2$ that works as an inter-appointment medication. Complete eradication cannot be achieved in a single visit irrigation (Sjögren et al., 1997). The intra-canal medicament can be prevented from escaping into the oral cavity by preventing the entry of fluids, microorganism, and other debris into the root canal (Ciftci et al., 2009). The presence of a satisfactory permanent coronal restoration is considered major postoperative factor influencing periapical health that provides seal against bacterial contamination (Ng et al., 2011). Dentists have a vital role in minimizing decontamination (Natto, 2014). To identify the requirement of intervention and remediation to improve the general outcome of root canal treatment, it is essential for dentists to study the level of knowledge, attitudes and behavior of disinfection. This study aims to evaluate the knowledge of dental practitioners regarding decontamination methods, as well as their reported practices of materials and techniques used during root canal treatment in some governmental and private practice clinics in the city of Jeddah.

2. Material and methods

2.1. Study design and duration

Cross-sectional analysis was employed to assess the knowledge of dental practitioners regarding decontamination methods. The study was conducted from 2016 to 2017 among 103 dentists, who performed root canal treatment.

2.2. Ethical approval

Confidentiality was ensure among the recruited participants. Institutional Review Board committee at King Abdul-Aziz University, Faculty of Dentistry (KAUFD) approved this study. The study procedure was according to the study was in full accordance with the World Medical Association Declaration of Helsinki.

2.3. Inclusion and exclusion criteria

Dentists were selected randomly from different private and governmental hospitals in Jeddah. Random sampling was conducted in a way that every individual had equal chance to be selected among the targeted population. The inclusion criteria included dentists who performed root canal treatment. Incomplete or non-complied questionnaires were excluded.

2.4. Data collection

Data was collected through questionnaires distributed to any dentist who performed root canal treatment in different types of clinical practice in Jeddah, Saudi Arabia (Table 1). The questionnaires were distributed via email, having two sections as below;

- First section gathered demographic details of the dentists including; gender, educational degree, place of work, number of years of practice, number of cases handled per month etc.
- Second section addressed the participant's clinical practice such as: the use of rubber dam, different root canal irrigants, and intracanal medications used between appointments, mechanical irrigation devices and coronal seal after root canal treatment.

All questions required single answer choice except for a few questions about practices that allowed multiple answers.

Table 1 Demographic details of the respondents.

Measure	Items	No.	Percentage
Name of government organization	King Abdul-Aziz University Dental Hospital	43	51.1%
	Ministry of Health General Dental Clinics	11	13.0%
	King Fahad Armed Forces Hospital	19	22.6%
	National Guard Health Affairs	11	13.0%
Type of private setting	Hospital setting	8	25.0%
	Polyclinic setting	18	56.2%
	Independent setting	6	18.7%
Years of Experience	< 1 year	34	33.0%
	1–5 years	48	46.6%
	6–10 years	7	6.8%
	> 10 years	14	13.6%

Table 2 Frequency about knowledge regarding each material.

Material	Correct Answer	Percentage
NaOCl	Remove the organic material from root canal	66.0%
	broad spectrum antimicrobial agent	58.3%
	1.5% −2.5%	57.3%
	5% −7%	25.2%
CHX	broad spectrum antimicrobial agent	71.8%
	10%-15%	12.2%
Chelating agent	remove the nonorganic part of smear layer	63.1%
	15%	34.0%
$Ca(OH)_2$	Antimicrobial agent	81.6%
	obliterate the canal space to prevent bacterial growth	46.6%
	1 week	58.3%

2.5. Statistical analysis

Data gathered through the questionnaire was coded and analyzed using SPSS version 20.0. Central tendency and dispersion were determined through descriptive analysis that helped in building understanding of the general characteristics of the study population. The association between different variables was established using chi-square test.

3. Results

The response rate was much higher from the governmental sector (81%) as compared to the private sector (17%). The demographic details of the respondents have been presented in Table 1. Majority of the respondents (51.1%) were from King Abdul-Aziz University Dental Hospital, followed by King Fahad Armed Forces Hospital (22.6%). The respondents were either from polyclinic setting (56.2%), hospital setting (25.0%), or independent setting (18.7%). Majority of the respondents (46.6%) had experience of 1 – 5 years; whereas, 33% had experience of < 1 year. It was shown that sodium hypochlorite (NaOCl) was the best root canal irrigant for majority of the dentists (66%); while, 58.3% knew the actions of this material. The action of chlorhexidine gluconate (CHX), chelating agents, and $Ca(OH)_2$ were known by 71.8%, 63.1%, and 46.6% of the study population, respectively (Table 2).

Rubber dam was used by the majority of dentists (82.5%) for isolation; however, its routine use was reported by only 63.1% of them. The remaining 18.4% reported the use of partial isolation methods. Disapproval from the patient side (14.6%) and increased time consumption (15.5%) were considered as the most common reasons hindering the adoption of using rubber dam. More practitioners (95.2%) from governmental sector reported using rubber dam in their practice as compared to practitioners from private sector (27.8%) ($p < 0.01$). In both the sectors, sodium hypochlorite was the most commonly used irrigant. Chelating agents were used by 13.0% of practitioners in governmental sector and 11.0% of practitioners in private sector. Calcium hydroxide as intracanal medicament was used more frequently in the governmental (29.8%) than in the private sector (11.8%) ($p < 0.05$). The mechanical irrigation devices were used by 2.4% of practitioners in the governmental sector only (Table 3).

Table 4 has shown significant difference in the level of knowledge about action and effective concentrations of certain irrigants such as EDTA, among the interns and dentists. There was no difference between interns and general dentists in practicing techniques like; using rubber dam, irrigation solutions, or intracanal medication. Table 5 illustrated the use of mechanical irrigation devices and educational degree were significantly associated ($p < 0.01$).

4. Discussion

The study employed a cross-sectional design based on questionnaire to demonstrate the level of differences between dental practice in both private and governmental sectors. Rubber dam is known as the standard of care during root canal treatment. In this study, 82.5% of the participants used rubber dam in both public and private sectors. These results were inconsistent with the study performed by Al-Fouzan (2010) showing that only 3% of the involved practitioners used rubber dam. More than 80% of the practitioners used sodium hypochlorite in their routine practice. Similar to this, a study conducted by Natto (2014) reported that 70% of the dentists use sodium hypochlorite. However, it contradicts Unal et al. (2012), who found that only 25% of practitioners used sodium hypochlorite during endodontic treatment.

Disinfection during root canal treatment is traditionally performed by introducing the solution into the root canals that allow it to flow and flush out of the access cavity, passively. It is difficult to remove the bacterial biofilms from all the aspects of root canal system because of the internal complexity of the system. Effective removal of smear layer and disinfecting root canals is possible through active irrigation and mechanical means as it favors further penetration of irrigating solutions into the root canal spaces. This sort of penetration develops contact between the irrigating solution and parts of the canal walls that were not possible to reach (Basrani, 2011). The frequency of use of active irrigation techniques by dental practitioners was not investigated in the current report. Active

Table 3 Association between practice and place of work.

Practice		Private sector		Governmental sector		p-value
		No.	%	No.	%	
Use of rubber dam		5	27.8%	80	95.2%	0.000**
Use of Sodium hypochlorite, (NaOCl)	Always	14	82.4	72	85.7	0.263
	Sometimes	2	11.8	12	14.3	
	Never	1	5.9	0	0	
Chelating agent (like EDTA or MTAD)	Always	2	11.1	11	13.3	0.969
	Sometimes	13	72.2	61	73.5	
	Never	3	16.7	11	13.3	
Intra canal medication calcium hydroxide ($Ca(OH)_2$)	Always	2	11.8	25	29.8	0.018*
	Sometimes	12	70.6	58	69	
	Never	3	17.6	1	1.2	
Use mechanical irrigation devices (like EndoVac system)	Always	0	0	2	2.4	0.744
	Sometimes	1	5.6	13	15.5	
	Never	17	94.4	69	82.1	

* $p < 0.05$.
** $p < 0.01$

Table 4 Association between educational degree and knowledge.

Practice	Measure	Educational Degree				
		General Dentist		Intern		p-value
		No.	%	No.	%	
The action of Sodium hypochlorite (NaOCl):	Remove the organic material from root canal	32	59.3	11	57.9	0.353
	broad spectrum antimicrobial agent	32	59.3	11	57.9	0.956
The effective and safe concentration of Sodium hypochlorite (NaOCl):	1.5% −2.5%	26	48.1	10	52.6	0.384
	5% −7%	14	25.9	4	21.1	0.616
The action of chlorhexidine (CHX):	Broad spectrum antimicrobial agent	36	66.7	10	52.6	0.189
The effective and safe concentration of chlorhexidine (CHX):	10%-15%	7	14.0	0	0.0	0.599
The action of the chelating agent like (EDTA or MTAD)	Remove the nonorganic part of smear layer	30	55.6	11	57.9	0.345
The effective concentration of EDTA	15%	10	18.5	1	5.3	0.000**
Intra canal medication calcium hydroxide ($Ca(OH)_2$):	Antimicrobial agent	39	72.2	17	89.5	0.421
	Obliterate the canal space to prevent bacterial growth	28	51.9	4	21.1	0.085
The duration of calcium hydroxide ($Ca(OH)_2$) to start its effect:	1 week	32	59.0	4	21.1	0.322

** $p < 0.01$

irrigation in the field of endodontics tends to initiate fluid hydrodynamics for improving the disinfection procedures. It plays an important role in the cleaning of well-shaped canals that include; lateral canals, anastomoses, dentinal tubules, webs, and fins.

Majority of the dentists reported that they placed temporary restorations, immediately after root canal therapy. This may be due to various reasons; for instance, referral to another dentist for placing restoration and lack of knowledge regarding the detrimental effect of not placing a final restoration immediately. The placement of temporary restoration after root canal increases the risk of developing tooth fracture and coronal leakage. Moreover, there is increase in the microbial penetration within the endodontic cavities with temporary filling materials, which has detrimental effect on the long-term prognosis of endodontic therapy (Cardoso et al., 2014). Previous studies were consistent with the results of the present study, which showed that there should not be long gap between root canal filling and final coronal sealing (Estrela et al., 2008; Kayahan et al., 2008; Cardoso et al., 2014).

Collagen depletion is experienced during the process of endodontic treatment, which decreases the dentine elasticity predisposing to fractures during the shearing forces (Eliyas et al., 2015). The present study showed significant difference in the level of knowledge about the action and effective concentrations of certain irrigants among the general dentists and interns. The results depicted that majority of the general practitioners did not follow the current recommended

Table 5 Association between educational degree and years of experience with practicing technique.

Practice	Measure	Educational degree				Years of experience							
		General dentist		Intern		(< 1year)		(1–5) years		(6–10) years		(10 <) years	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Rubber dam use		40	74.1	19	100	32	100	37	77.1	5	71.4	9	64.3
p-value		0.824				0.197							
Chelating agent (like EDTA or MTAD)	Always	4	7.5	2	10.5	5	15	4	8.5	2	28.6	2	14.3
	Sometimes	40	75.5	14	73.7	26	77	34	72.3	5	71.4	10	71.4
	Never	9	17	3	15.8	3	8.8	9	19.1	0	0	2	14.3
p-value		0.427				0.571							
Intra canal medication calcium hydroxide ($Ca(OH)_2$)	Always	15	28.3	5	26.3	9	27	15	31.3	1	14.3	2	15.4
	Sometimes	35	66	13	68.4	24	71	32	66.7	6	85.7	9	69.2
	Never	3	5.7	1	5.3	1	2.9	1	2.1	0	0	2	15.4
p-value		0.754				0.334							
Use mechanical irrigation devices (EndoVac system)	Always	1	1.9	0	0	0	0	1	2.1	0	0	1	7.1
	Sometimes	4	7.4	1	5.3	3	8.8	4	12.5	3	42.9	2	14.3
	Never	49	90.7	18	94.7	31	91	41	85.4	4	57.1	11	78.6
p-value		0.001**				0.195							

** $p < 0.01$

endodontic irrigation techniques in several areas. There is a need of upgrading and monitoring the irrigation techniques adopted by the dental practitioners as well as the interns to ensure high success rates of the endodontic treatment.

Rubber dam was used by majority of the practitioners (82.5%) for isolation; whereas, the remaining used partial isolation methods because rubber dam was time consuming and disapproved by the patients. Whereas, Unal et al. (2012) reported about the use of rubber dam in improving the quality and success of root canal therapy. A study similar to the present study showed that rubber dam isolation was applied by 56.3% of the dentists; whereas, still 24.2% used partial isolation for root canal therapy (Bogari et al., 2019). These results are in line with the conclusions drawn in the present study. However, previous studies conducted in Saudi Arabia have reported 9–14.7% use of rubber dam by dentists after root canal treatment (Iqbal et al., 2014; Mathew et al., 2015), 19% in U.S. (Jenkins et al., 2001), 5.1% in Turkey (Unal et al., 2012), and 3.2% in India (Gaikwad et al., 2013). The promising treatment outcomes and resolution of periapical infections is ensured by decreasing the chances of bacterial infection after root canal therapy. However, this can only be achieved if the dental practitioners are well aware about decontamination during root canal treatment.

Previous studies have reported that rubber dam is essential and used as a standard of care during the non-surgical root canal treatment (European Society of Endodontology, 2006; American Association of Endodontists, 2010). Unlike the present study, Alrahabi and Ahmad (2015) showed that only 3% of the dentists used rubber dam during root canal treatment. On the contrary, a study conducted in USA showed that around 60% of the dentists used rubber dam during the root canal treatment. The current trends and adoption of new technologies in the field of dentistry was evaluated by AlRahabi (2016). The general practitioners reported that none of them used any magnification device while conducting the root canal treatment. The study also reported that the adoption of new technology by the general practitioners was at low rate in the private dental clinics.

Adou-Assoumou et al. (2016) revealed that approximately 76% of practitioners were not aware of the recommended concentration of sodium hypochlorite that should be used. The present study has reported that effective concentration of sodium hypochlorite was not known by 43% of practitioners. Chelating agents in the present study were used by 12.7% of participants; whereas, Unal et al. (2012) reported the use of chelating agents by 32.4% of participants. The present study has also reported that calcium hydroxide was used by 26.5% of the practitioners, in contrast to 53.2% of practitioners in Unal et al. (2012), 26% in Natto (2014), and 37.77% in Ravanshad et al. (2008). The present study has reported significant association between different root canal disinfection techniques that include the use of rubber dam ($P = 0.000$) and calcium hydroxide ($P = 0.018$).

5. Conclusion

Results have depicted significant difference in practicing root canal disinfection techniques between dentists in governmental and private sectors. There is an insignificant difference in the degree of knowledge between both of them. These results recommend the implementation of improved techniques regarding decontamination methods by creating stricter clinical protocols and conducting continuing educational workshops. In future, the scope of the study can be expanded on a larger sample of dental practitioners to allow a greater understanding of the challenges they face in carrying out efficient decontamination practices during root canal treatment.

Ethical approval

The proposal of the article titled "Knowledge and Practices of Decontamination during Root Canal Treatment by Dentists in Jeddah" has been granted the ethical approval from Committee of Department of Endodontics Proposal Number 039–15, Faculty of Dentistry, King Abdul Aziz University, Jeddah, Saudi Arabia 04/10/2015.

Declaration of Competing Interest

The author declares no conflict of interest.

Acknowledgements

The author would like to acknowledge the efforts of the dental interns who assisted in data collection for this study. In addition, the author is very thankful to all the associated personnel in any reference that contributed in/for the purpose of this research.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

Adou-Assoumou, M., Krah-Sinan, A., Koffi-Gnagne, Y., et al, 2016. Protocol for root canals' irrigation in endodontic practice in ivory coast: a survey of 100 dentists. J. Dent. Oral Care Med. 3, 303.

Al-Fouzan, K.S., 2010. A survey of root canal treatment of molar teeth by general dental practitioners in private practice in Saudi Arabia. Saudi Dent. J. 22, 113–117. https://doi.org/10.1016/j.sdentj.2010.04.003.

AlRahabi, M., 2016. Attitudes of general practice dentists in private dental clinics in Almadinah Almunawarah toward novel endodontic technologies. Giornale Italiano di Endodonzia. 30, 10–13.

Alrahabi, M., Ahmad, M.S., 2015. Knowledge regarding technical aspects of non-surgical root canal treatment in Al-Madinah Al-Munawarah private dental centers. Saudi Endodont. J. 5, 155.

American Association of Endodontists. 2010. American Association of Endodontists Position Statement: Dental Dams. Chicago: American Association of Endodontists; 2010. Retrieved from: http://www.aae.org/guidelines/uploadedfiles/publications_and_research/guidelines_and_position_statements/dentaldamstatement.pdf [Last accessed on 2014 May]. Back to cited text no. 19.

Basrani, B., 2011. Irrigation in endodontic treatment. Alpha Omegan, 104.

Baumgartner, J.C., Johal, S., Marshall, J.G., 2007. Comparison of the antimicrobial efficacy of 1.3% NaOCl/BioPure MTAD to 5.25% NaOCl/15% EDTA for root canal irrigation. J. Endod. 33, 48–51. https://doi.org/10.1016/j.joen.2006.08.007.

Bogari, D.F., Alzebiani, N.A., Mansouri, R.M., et al, 2019. The knowledge and attitude of general dental practitioners toward the proper standards of care while managing endodontic patients in Saudi Arabia. Saudi Endodont. J. 9, 40.

Cardoso, A.S., Silva, N.C., Silva, J.M., et al, 2014. Assessment of coronal leakage of a new temporary light-curing filling material in endodontically treated teeth. Ind. J Dent. Res. 25, 321. https://doi.org/10.4103/0970-9290.138329.

Çiftçi, A., Vardarlı, D.A., Sönmez, I.Ş., 2009. Coronal microleakage of four endodontic temporary restorative materials: an in vitro study. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. 108, e67–e70. https://doi.org/10.1016/j.tripleo.2009.05.015.

Eliyas, S., Jalili, J., Martin, N., 2015. Restoration of the root canal treated tooth. Br. Dent. J. 218, 53. https://doi.org/10.1038/sj.bdj.2015.27.

Estrela, C., Leles, C.R., Hollanda, A.C.B., et al, 2008. Prevalence and risk factors of apical periodontitis in endodontically treated teeth in a selected population of Brazilian adults. Braz. Dent. J. 19, 34–39. https://doi.org/10.1590/s0103-64402008000100006.

European Society of Endodontology. 2006. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. International Endodontic Journal. 39, pp. 921–930.

Gaikwad, A., Jain, D., Rane, P., et al, 2013. Attitude of general dental practitioners toward root canal treatment procedures in India. J. Contemp. Dent. Pract. 14, 528. https://doi.org/10.5005/jp-journals-10024-1356.

Gomes, B.P., Vianna, M.E., Zaia, A.A., et al, 2013. Chlorhexidine in endodontics. Braz. Dent. J. 24, 89–102. https://doi.org/10.1590/0103-6440201302188.

Haapasalo, M., Endal, U., Zandi, H., et al, 2005. Eradication of endodontic infection by instrumentation and irrigation solutions. Endod. Topics 10, 77–102. https://doi.org/10.1111/j.1601-1546.2005.00135.x.

Hülsmann, M., 2016. Prevention and management of problems during root canal treatment–a problem-based approach to root canal treatment. Part II. ENDO (Lond Engl) 10, 141–151. https://doi.org/10.1111/j.1601-1546.2011.00264.x.

Iqbal, A., Akbar, I., Qureshi, B., et al, 2014. A survey of standard protocols for endodontic treatment in north of KSA. ISRN Dent., 2014.

Jenkins, S.M., Hayes, S.J., Dummer, P.M.H., 2001. A study of endodontic treatment carried out in dental practice within the UK. Int. Endod. J. 34, 16–22. https://doi.org/10.1046/j.1365-2591.2001.00341.x.

Kayahan, M.B., Malkondu, Ö., Canpolat, C., et al, 2008. Periapical health related to the type of coronal restorations and quality of root canal fillings in a Turkish subpopulation. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. 105, e58–e62. https://doi.org/10.1016/j.tripleo.2007.07.044.

Kulild, J.C., 2013. Using a rubber dam. Dent. Assist. J. 144, 572. https://doi.org/10.14219/jada.archive.2013.0163.

Mathew, S.T., Al Nafea, M., 2015. An evaluation of the current endodontic trends among the general dental practitioners and specialist in Riyadh, KSA. Int. J. Innov. Educ. Res. 3.

Natto, Z.S., 2014. A survey of root canal treatment in Saudi Arabia: a pilot study. Oral Health Dent. Manag. 13, 354–358.

Ng, Y.L., Mann, V., Gulabivala, K., 2011. A prospective study of the factors affecting outcomes of nonsurgical root canal treatment: part 1: periapical health. Int. Endod. J. 44, 583–609. https://doi.org/10.1111/j.1365-2591.2011.01872.x.

Panuganti, V., Vivek, V.J., Jayashankara, C.M., et al, 2016. Gutta-percha disinfection: a knowledge, attitude, and practice study among endodontic postgraduate students in India. Saudi Endodont. J. 6, 127. https://doi.org/10.4103/1658-5984.189353.

Ravanshad, S., Sahraei, S., Khayat, A., 2008. Survey of endodontic practice amongst Iranian dentists participating restorative dentistry congress in Shiraz, November 2007. Iran Endod. J. 2, 135.

Sjögren, U., Figdor, D., Persson, S., et al, 1997. Influence of infection at the time of root filling on the outcome of endodontic treatment of teeth with apical periodontitis. Int. Endod. J. 30, 297–306. https://doi.org/10.1046/j.1365-2591.1997.00092.x.

Unal, G.C., Kaya, B.U., Tac, A.G., et al, 2012. Survey of attitudes, materials and methods preferred in root canal therapy by general dental practice in Turkey: part 1. Eur. J. Dent. 6, 376.

Zehnder, M., 2006. Root canal irrigants. J. Endod. 32, 389–398. https://doi.org/10.1016/j.joen.2005.09.014.