

ORIGINAL RESEARCH

Primary tooth vital pulp therapy techniques taught in dental schools in Saudi Arabia: a cross-sectional study

Ayman M. Sulimany^{1,*}, Mannaa Aldowsari¹, Saad Bin Saleh¹, Faisal F. Almajhdi², Omar A. Al Ajlan², Ibrahim M. ALSayyari², Khalid M. Alshehri², Hebah M. Hamdan³

¹Department of Pediatric Dentistry and Orthodontics, College of Dentistry, King Saud University, 11545 Riyadh, Saudi Arabia

²College of Dentistry, King Saud University, 11545 Riyadh, Saudi Arabia

³Department of Periodontics and Community Dentistry, College of Dentistry, King Saud University, 11545 Riyadh, Saudi Arabia

***Correspondence**

asulimany@ksu.edu.sa

(Ayman M. Sulimany)

Abstract

Worldwide, dental schools employ varying approaches to teaching vital pulp therapy (VPT) for primary teeth. However, little is known about the VPT techniques taught in dental schools in Saudi Arabia. Therefore, this study aimed to describe the approaches of VPT for primary teeth taught in undergraduate dental schools in Saudi Arabia. A nationwide cross-sectional study was conducted between January and June 2022, using an online questionnaire distributed to pediatric dentistry faculty members at all dental schools in Saudi Arabia. The questionnaire collected information on socio-demographic characteristics, educational background, work setting, and VPT teaching approaches. Descriptive statistics and logistic regression models assessed the association between participants' characteristics and the VPT techniques taught. Seventy-seven faculty members from 17 out of 27 dental colleges in Saudi Arabia participated in the study. Most respondents reported teaching indirect pulp capping (95%), with glass ionomer cement and calcium hydroxide being the most popular materials. Only 11 participants (14%) taught direct pulp capping, with mineral trioxide aggregate and calcium hydroxide being the most commonly used materials. Pulpotomy procedures were taught in all dental schools, with formocresol being the most commonly used medicament (84%). No significant associations were found between faculty member characteristics and the likelihood of teaching indirect pulp capping. However, older age categories had a significantly higher chance of teaching direct pulp capping (trend odds ratio: 2.27, $p = 0.02$). In conclusion, most faculty members (95%) reported teaching indirect pulp capping using glass ionomer cement and calcium hydroxide for primary teeth. Only 14% of the respondents taught direct pulp capping, and the use of mineral trioxide aggregate for direct pulp capping appears to be increasing. Formocresol was the most commonly used pulpotomy medicament. Further research is needed to investigate factors that influence the teaching of VPT for primary teeth in Saudi Arabia.

Keywords

Calcium hydroxide; Direct pulp capping; Indirect pulp capping; MTA; Pulp therapy; Pulpotomy

1. Introduction

Dental caries is a chronic infectious disease that demineralizes tooth structure [1]. Despite the global decline in the prevalence of dental caries over the years, a study has shown that it remains a public health concern, particularly affecting young children in Saudi Arabia, with up to 80% of primary teeth being affected [2]. Despite improvements in caries detection and management approaches, premature loss of primary teeth remains a problem [3]. Clinicians may encounter difficulties in diagnosing and treating deep carious lesions approximating the pulp of deciduous teeth. The physiological, anatomical, and pathological variations between primary and permanent teeth further complicate treatment choices [4].

In dentistry, various methods have been proven to be effec-

tive and conservative in the early detection and management of dental caries. The choice of restorative and preventive interventions is primarily based on the patient's caries risk level [5]. According to the American Academy of Pediatric Dentistry (AAPD), there are three modalities of vital pulp therapy (VPT) for treating deep dentin caries lesions approaching the pulp in vital deciduous teeth. These include (1) pulpotomy, a clinical technique that involves the removal of the coronal pulp, control of pulpal hemorrhage, and treatment of the remaining vital radicular pulp with a long-term clinically successful medicament; (2) indirect pulp treatment (IPT); a procedure that aims to preserve the pulp by leaving the deepest caries near the pulp, also known as indirect pulp cap (IPC); and (3) direct pulp cap (DPC), a procedure where a pinpoint pulp exposure resulting from traumatic exposure or during

cavity preparation is covered with a biocompatible radiopaque material [6]. DPC was not recommended for treating primary teeth for a long period [7]. However, the implementation of VPT in primary teeth is not without controversy, as no single treatment is suitable for all clinical cases [8].

The pulpotomy procedure has been widely used as a VPT for primary teeth. Bossù *et al.* [9] reported a high clinical and radiographic success rate of up to 96% for mineral trioxide aggregate (MTA). Sahin *et al.* [10] found that IPT exhibited high clinical and radiographic success rates over a 24-month follow-up period for treated primary molars. Additionally, Gizani *et al.* [11] reported a success rate of up to 94% for IPC at a 2-year follow-up. With advancements in dental treatment techniques, practitioners are increasingly adopting minimally invasive approaches. Recently, the AAPD stated that the use of a DPC for pinpoint pulp exposure in primary teeth is no longer contraindicated [6].

Several studies have investigated VPT teaching methods in undergraduate dental courses at dental schools worldwide [12–16]. The current evidence reveals inconsistencies in the materials and techniques taught for VPT in primary teeth across dental schools [16]. For instance, in the United Kingdom and Ireland, formocresol is no longer the primary pulp medicament taught in dental schools. Instead, most dental schools teach the use of ferric sulfate for vital pulpotomy [14]. In contrast, a study conducted in the United States to analyze pulpotomy techniques taught in pediatric residency programs found that 82% of graduate residency programs still utilize formocresol as a pulpotomy medicament for primary teeth [16]. Conversely, in Europe, there has been an increasing trend toward using new materials, such as MTA, for pulpotomy in primary teeth [13].

There are significant variations in the teaching of VPT techniques, such as IPC and DPC, across dental schools worldwide. Ní Chaollaí *et al.* [14] discovered consistent teaching approaches between dental schools in Ireland and the UK regarding IPC and DPC techniques, with calcium hydroxide ($\text{Ca}(\text{OH})_2$) being the most commonly used medicament for both techniques. Another study found that less than half of European dental schools include DPC in their curriculum, and when taught, $\text{Ca}(\text{OH})_2$ followed by MTA are the primary medicaments used [13]. Similarly, less than a third of dental schools and dental graduates in the United States perform DPC on primary teeth using glass ionomer [12]. To our knowledge, there is a dearth of studies examining the teaching methods of VPT in undergraduate dental schools in Saudi Arabia. Therefore, our study aimed to assess the approaches to teaching VPT for primary teeth to undergraduate dental students in dental schools in Saudi Arabia.

2. Material and methods

2.1 Study design and setting

This is a nationwide, investigator-initiated cross-sectional study that focused on pediatric dentistry faculty members from all dental schools in Saudi Arabia. The reporting of this study follows the guidelines outlined in the strengthening the reporting of observational studies in epidemiology (STROBE) statement [17].

2.2 Dental schools and participants

To be eligible for participation, dentistry faculty members had to have a formal affiliation with an undergraduate dental school in Saudi Arabia, either as full-time or part-time faculty members. There were no geographical restrictions regarding the location of their training. Both male and female participants, aged 30 to 75 years, were considered eligible. We included private and public institutions as long as they offered undergraduate dental programs. Individuals who were unable to provide informed consent were excluded from the study.

2.3 Sampling

Participants were recruited for the study through a two-stage process. In the first stage, heads of dentistry departments were contacted *via* email, providing them with a detailed explanation of the study's objectives. Additionally, a hyperlink to access the questionnaire was included in the email, along with a request to distribute the survey among the pediatric dentistry department faculty members. In the second stage, the initially eligible participants were internally contacted within the dental schools and personally invited to complete the questionnaire.

2.4 Questionnaire and variables

We developed a questionnaire based on a previous study [13] as the foundation for our research. Specifically, the questionnaire for this study encompassed various questions and topics concerning VPT techniques. Socio-demographic information, including age, gender, nationality, affiliation, and academic rank, was collected. Age was categorized into four groups: <35, 35–40, 41–45 and >45 years. The questionnaire was accessible for completion between January and June 2022.

We also gathered information pertaining to the respondents' postgraduate pediatric dentistry clinical training. This included details about the institution where they received their training, the type of postgraduate training they underwent, and the year in which they obtained their training certificate. Furthermore, the questionnaire encompassed queries regarding IPC, such as the teaching and using materials like calcium hydroxide, zinc oxide, glass ionomer, and others. It also included questions concerning direct pulp therapy, specifically addressing the use of hard-setting calcium hydroxide, MTA, total-etch technique, glass ionomer cement (GIC), Ledermix paste, and other materials. The questionnaire further inquired about using various materials for vital pulpotomies, including ferric sulfate, formocresol, MTA, calcium hydroxide, laser, or no medicament. Participants were allowed to select multiple options when indicating the dental materials used. Additional questions focused on the choice of material for pulpotomy coverage, the type of restoration employed following a vital pulpotomy, and whether students were instructed to take a postoperative radiograph. Complete details regarding the questionnaire can be found in **Supplementary material**.

2.5 Statistical analysis

Assuming that 85% of the participants would teach indirect pulp capping [12], the study would require a sample size of 54 participants to estimate the expected proportion with a

10% absolute precision and 95% confidence intervals. The determination of the sample size was conducted using the G*Power software package (Version 3.1.9.4, Kiel University, Kiel, Germany).

Variables with an approximately normal distribution were summarized using means (standard deviations, SD), while variables with a skewed distribution were summarized using medians (interquartile ranges, IQR). Categorical variables were presented as numbers (percentages). Act 95% confidence intervals (95% CIs) for proportions were calculated using the Clopper-Pearson method. Exploratory analyses were conducted using logistic regression models to investigate the associations between the teaching of indirect or direct pulp capping and socio-demographic, institutional, and clinical training characteristics. In cases where zero events were observed, exact logistic regression was utilized. Statistical analyses were performed using SAS 9.4 software (SAS Institute, Inc., Cary, NC, USA). A two-sided *p*-value of less than 0.05 was considered statistically significant.

3. Results

3.1 Characteristics of the participating institutions and dental professionals

Table 1 presents a summary of the key characteristics pertaining to the participating institutions and dental professionals. Out of the 27 dental schools in Saudi Arabia that were contacted, 17 of them participated, resulting in a participation rate of 74.1%. Among the participating institutions, 12 (71%) were public. The median (IQR) number of dental professionals per institution was three (2 to 4). Of the 77 participants, 40 (52%) were male, and the age group with the highest frequency was 35–40 years (36%). In total, 57 participants (74%) received pediatric dentistry training internationally, primarily from institutions in the United States and the United Kingdom.

3.2 Teaching of IPT for primary teeth

Among the 77 participants, 73 (95% CI, 87–99%) reported engaging in teaching IPT. Of these, 52 (71%) stated that they teach the utilization of GIC, while 44 (60%) reported teaching the application of calcium hydroxide. Additional information regarding the materials employed by dental professionals who teach IPT for primary teeth in Saudi Arabia can be found in Table 2.

3.3 Teaching of DPC for primary teeth

Out of the 77 participants, 11 (14%, 95% CI, 7–24%) reported teaching DPC. The most commonly employed materials were MTA, used by seven out of 11 participants (64%), and calcium hydroxide, used by six out of 11 participants (54%). Table 2 shows additional information about the materials utilized by dental professionals teaching DPT for primary teeth in Saudi Arabia.

3.4 Teaching of pulpotomy in primary teeth

Table 3 illustrates the preferences for medicaments used in pulpotomy procedures among dental professionals who teach

TABLE 1. Characteristics of participants and their institutions.

Variable	n	(%)
Sex		
Female	37	48.05
Male	40	51.95
School		
Governmental	63	81.82
Private	14	18.18
Age		
Less than 35 yr	19	24.68
35–40 yr	28	36.36
41–45 yr	18	23.38
More than 45 yr	12	15.58
Academic position		
Assistant professor	52	67.53
Associate professor	8	10.39
Demonstrator	4	5.19
Lecturer	4	5.19
Professor	9	11.69
Country of postgraduate pediatric dentistry clinical training		
Saudi Arabia	20	25.97
UK	19	24.68
USA	21	27.27
Other	17	22.08

TABLE 2. Medicaments taught in Saudi dental schools for direct and indirect primary pulp therapy procedures.

	n	%
Teaching indirect pulp therapy		
Yes	73	94.81
No	4	5.19
Medicaments taught for indirect pulp therapy*		
Calcium hydroxide	44	60.27
Glass ionomer cement	52	71.23
Mineral trioxide aggregate (MTA)	4	5.48
Bioceramic	1	1.40
Zinc oxide eugenol	1	1.40
Teaching direct pulp capping		
Yes	11	14.29
No	66	85.71
Medicaments taught for direct pulp therapy*		
Calcium hydroxide	6/11	54.55
Mineral trioxide aggregate (MTA)	7/11	63.64
Glass ionomer cement	1/11	9.09
LedermixR	3/11	27.27

*More than one medication can be selected.

TABLE 3. Details of pulpotomy practices for primary teeth taught in Saudi Arabian dental schools.

Pulpotomy	n	%
Medicaments taught for vital pulpotomy*		
Ferric sulfate	20	25.97
Formocresol	65	84.42
Mineral trioxide aggregate (MTA)	47	61.04
Calcium hydroxide	4	5.19
Sodium hypochlorite	3	3.90
Biodentine	1	1.30
No medicament	1	1.30
First-choice medicament		
Ferric sulfate	11	14.29
Formocresol	28	36.36
Mineral trioxide aggregate (MTA)	35	45.45
Calcium hydroxide	3	3.90
Material placed over pulp following pulpotomy*		
Zinc oxide and eugenol cement	62	80.51
Reinforced glass ionomer	20	25.97
Restoration taught following pulpotomy*		
Preformed metal crown	77	100.00
Composite resin	0	0.00
Amalgam	0	0.00
Glass ionomer cement	0	0.00
Taking radiograph following pulpotomy		
Yes	34	44.16
No	43	55.84
Timing of the radiograph**		
Immediately	21	67.74
At the 6 mon follow-up	3	9.68
At the 12 mon follow-up	1	3.23
At the next appropriate time according to the caries risk	6	19.35

*More than one medication can be selected.

**There were three subjects with missing information regarding the timing of the radiograph after pulpotomy procedure.

in Saudi Arabia. Significantly diverse practices were observed in the selection of medicaments for pulpotomy in primary teeth. The most frequently utilized medicament was formocresol, with 65 participants (84%) reporting its usage, whereas biodentine was the least preferred option, mentioned by only one participant (1.3%).

When given the option to choose between two or more medicaments, 35 participants (45%) indicated that their preferred first choice would be MTA. The second most commonly selected option was formocresol, chosen as the first preference by 28 participants (36%).

Among the 77 participants, 62 (80.5%) preferred utilizing zinc oxide and eugenol cement as the material for placement over the pulp chamber. Regarding the final restoration follow-

ing vital pulpotomy of primary teeth, all respondents (100%) favored using a stainless-steel crown.

Out of the 77 respondents, 34 (44.2%) indicated that they teach students to take a postoperative radiograph. Among those who instruct their student take x-rays, the majority (21, 67.7%) recommended taking the radiograph immediately after the restoration.

3.5 Factors associated with the teaching methods of VPT

Our analysis found no significant associations between the examined socio-demographic, institutional, and clinical training characteristics and the likelihood of teaching IPC (Table 4). However, when examining direct pulp capping (Table 5), we

TABLE 4. Associations of socio-demographic, institutional and clinical training characteristics with teaching of indirect pulp capping (IPC) for primary teeth.

Variable	Teaches IPC, no (%)		OR (95% CI)*	p
	Yes	No		
Age (yr)				
<35	18 (94.7)	1 (5.3)	Ref.	
35–40	27 (96.4)	1 (3.6)	1.50 (0.09 to 25.55)	0.78
41–45	17 (94.4)	1 (5.6)	0.94 (0.05 to 16.33)	0.97
>45	11 (91.7)	1 (8.3)	0.61 (0.03 to 10.79)	0.74
Sex				
Female	35 (94.6)	2 (5.4)	Ref.	
Male	38 (95.0)	2 (5.0)	1.08 (0.15 to 8.13)	0.94
School type				
Public	59 (93.7)	4 (6.3)	Ref.	
Private	14 (100.0)	0	1.20 (0.14 to +Inf)	0.88
Academic position				
Assistant professor	49 (94.2)	3 (5.8)	Ref.	
Associate professor	8 (100.0)	0	0.60 (0.06 to +Inf)	>0.99
Demonstrator	4 (100.0)	0	0.29 (0.03 to +Inf)	>0.99
Lecturer	4 (100.0)	0	0.29 (0.03 to +Inf)	>0.99
Professor	8 (88.9)	1 (11.1)	0.50 (0.03 to 28.91)	0.96
Clinical training**				
Saudi Arabia	19 (95.0)	1 (5.0)	Ref.	
UK	17 (89.5)	2 (10.5)	0.46 (0.01 to 9.51)	0.96
USA	20 (95.2)	1 (4.8)	1.05 (0.01 to 86.73)	>0.99
Other	17 (100.0)	0 (0.0)	0.85 (0.21 to +Inf)	>0.99

Ref.: reference group; OR: odds ratio; 95% CI: 95% confidence interval; +Inf: upper limit of the confidence interval could not be estimated.

*When there is a zero event cell in a variable, exact logistic regression was used for analysis.

**Refers to the country where participants received their postgraduate pediatric dentistry clinical training.

observed a significant trend indicating that older age categories had a higher likelihood of teaching DPC (odds ratio for trend: 2.27, 95% CI: 1.11–5.04, $p = 0.02$).

4. Discussion

4.1 Principal findings

This nationwide survey, which achieved a participation rate of 74.1%, provides valuable insights into the current teaching practices of VPT for primary teeth among undergraduate dental schools in Saudi Arabia. According to our findings, 95% of dental professionals at Saudi dental schools teach IPC, predominantly utilizing GIC and calcium hydroxide as the preferred materials. In contrast, only 14% of faculty members reported teaching DPC, with the most commonly used materials being MTA and calcium hydroxide. Notably, formocresol emerged as the most frequently employed medicament for pulpotomy, although MTA was favored when presented with multiple medicament options. Our analysis revealed no statistically significant associations, except for age, which

demonstrated a noteworthy correlation, indicating that older individuals were more inclined to teach DPC. Nevertheless, the magnitude of this association remains uncertain due to sparse data.

4.2 Comparison with previous studies

Several studies have been conducted globally to evaluate the teaching methods of VPT in undergraduate dental students at dental schools. However, to the best of our knowledge, none of these studies have specifically been undertaken in Saudi Arabia.

IPC, as a conservative approach to pulp therapy, prioritizes the preservation of tooth vitality. In our study, a significant proportion of participants expressed their preference for teaching IPC in the context of deciduous teeth. Moreover, most respondents favored using glass ionomer as the primary material, closely followed by calcium hydroxide. Notably, these findings are in line with several studies conducted in the USA and Colombia [12, 15, 16].

In the present study, a substantial percentage (85.7%) of

TABLE 5. Associations of socio-demographic, institutional and clinical training characteristics with teaching of direct pulp capping for primary teeth.

Variable	Teaches DPC, no. (%)		OR (95% CI)*	p
	Yes	No		
Age (yr)				
<35	0	19 (100.0)	Ref.	
35–40	4 (14.3)	24 (85.7)	3.93 (0.46 to +Inf)	0.23
41–45	3 (16.7)	15 (83.3)	4.47 (0.45 to +Inf)	0.21
>45	4 (33.3)	8 (66.7)	10.79 (1.22 to +Inf)	0.03
Sex				
Female	7 (18.9)	30 (81.1)	Ref.	
Male	4 (10.0)	36 (90.0)	0.48 (0.13 to 1.78)	0.27
School type				
Public	10 (15.9)	53 (84.1)	Ref.	
Private	1 (7.1)	13 (92.9)	0.41 (0.05 to 3.48)	0.41
Academic position				
Assistant professor	6 (11.5)	46 (88.5)	Ref.	
Associate professor	1 (12.5)	7 (87.5)	1.09 (0.02 to 11.5)	>0.99
Demonstrator	0 (0.0)	4 (100.0)	1.55 (0.00 to 14.3)	>0.99
Lecturer	2 (50.0)	2 (50.0)	7.21 (0.45 to 117.0)	0.19
Professor	2 (22.2)	7 (77.8)	2.16 (0.18 to 15.83)	0.67
Clinical training**				
Saudi Arabia	2 (10.0)	18 (90.0)	Ref.	
UK	1 (5.3)	18 (94.7)	0.50 (0.04 to 6.01)	0.59
USA	2 (9.5)	19 (90.5)	0.95 (0.12 to 7.46)	0.96
Other	6 (35.3)	11 (64.7)	4.90 (0.84 to 28.71)	0.08

Ref.: reference group. OR: odds ratio. 95% CI: 95% confidence interval. +Inf: upper limit of the confidence interval could not be estimated.

*When there is a zero event cell in a variable, exact logistic regression was used for analysis.

**Refers to the country where participants received their postgraduate pediatric dentistry clinical training.

respondents did not include DPC as a treatment modality for primary teeth in their teaching practices. These findings are consistent with previous studies [12, 14, 15, 18]. Only 14.3% of our sample reported teaching DPC for primary teeth, which is relatively low considering the growing body of evidence supporting its efficacy [6, 19–22]. However, this observation could be attributed to the recent statement by the AAPD indicating that DPC is not contraindicated for primary molars [6]. Interestingly, we observed a positive association between older age groups and a higher likelihood of teaching DPC. Several factors could explain why older dental professionals are more inclined to teach DPC. They may possess more experience with this technique, having been exposed to it throughout their careers. Additionally, their training may have occurred during a period when DPC was more commonly taught and practiced.

Several clinical studies have been conducted to evaluate the success rate of DPC for primary teeth. Ali *et al.* [19] conducted a clinical trial that reported a 74.7% success rate for DPC in primary molars after a 1-year follow-up. Similarly, a recent prospective randomized clinical trial demonstrated an acceptable success rate for asymptomatic carious primary

molars at a 13-month follow-up, utilizing three biocompatible materials [20]. Additionally, Dimitraki *et al.* [21] found that both DPC and pulpotomy exhibited acceptable success rates, with no significant difference in failure rates between the two methods after a 3-year follow-up. A recent systematic review emphasized that with the availability of advanced biocompatible materials, there is no evidence supporting the contraindication of DPC in primary teeth [22].

In Saudi Arabia, the teaching of VPT places a strong emphasis on the pulpotomy procedure, which remains the most commonly taught technique. Notably, formocresol emerges as the predominant medicament employed, aligning with findings from studies conducted in the USA, Colombia, and Brazil [12, 15, 18]. However, our results differ from studies conducted in Europe [13], Ireland and the UK [14], which have shown a decline in the use of formocresol in recent years, with ferric sulfate emerging as the preferred alternative. This shift can be attributed to increasing concerns regarding the toxicity and carcinogenicity of formocresol. In 2004, the International Agency for Cancer Research classified formocresol as carcinogenic to humans, leading to a reduction in its usage and a surge in the

adoption of alternative materials across Europe [23].

The widespread use of formocresol as the preferred medication in many countries can be attributed to various factors, including its affordability and widespread availability. These aspects likely contributed to the high percentage of formocresol usage observed in our study, particularly considering that most dental schools in Saudi Arabia receive government funding. However, when participants were asked about the possibility of transitioning to a different medicament, most preferred using MTA as the alternative choice. It is important to note that the success of any pulp therapy heavily relies on a well-sealed coronal restoration. In our study, all respondents unanimously agreed that stainless-steel crowns are the preferred option for the final coronal restoration following pulpotomy of primary teeth. Numerous studies have demonstrated the superior survival rates of stainless-steel crowns compared to other types of restorations [24, 25].

4.3 Limitations

The present investigation has several limitations that should be acknowledged. First, the study utilized an online questionnaire, offering advantages such as cost-effectiveness and time efficiency. However, it is important to recognize that online surveys may exclude eligible participants who currently lack internet access or may not be inclined to respond to online questionnaires. While it is impossible to completely eliminate the possibility that non-participants may possess different teaching practices and characteristics compared to participants, the high participation rate achieved (74.1%) reduces the risk of selection bias. Second, the study relied on self-reported data, which can be susceptible to response bias. Participants may have either over or under-reported their teaching practices, potentially influencing the accuracy of the findings. Third, the study exclusively focused on faculty members in Saudi Arabia, limiting the generalizability of the findings to other countries or regions. Fourth, the study solely examined undergraduate pediatric dental courses, and therefore, the results may not apply to postgraduate education or other advanced dental courses. Fifth, the study did not investigate the quality of teaching or the clinical outcomes associated with the various techniques. Consequently, it remains unclear whether the reported teaching practices are associated with improved or compromised clinical outcomes. Sixth, the sample size of our study was small, resulting in limited statistical power and impeding our ability to establish robust predictors for teaching IPC or DPC. Seventh, the underlying causes of the observed variations in teaching practices were not explored. Further research is warranted to gain a deeper understanding of these variations, preferences, and predictors that impact the adoption of new pulp therapy medications. This will facilitate the identification of areas for improvement in dental education and clinical practice within Saudi Arabia.

5. Conclusions

This nationwide survey found that 95% of respondents reported teaching IPC for primary teeth, primarily utilizing GIC and calcium hydroxide. However, only a small percentage

of respondents (14%) reported teaching DPC, despite a growing body of evidence supporting its efficacy. Formocresol emerged as the most commonly used medicament for pulpotomy, although there is a noticeable shift towards alternative materials like MTA. These findings provide valuable insights for dental educators and policymakers, emphasizing the need for further research to explore the factors that influence the teaching of VPT in Saudi Arabia.

ABBREVIATIONS

DPC, direct pulp capping; IPC, indirect pulp capping; VPT, vital pulp therapy.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on request from the corresponding author. The data are not publicly available.

AUTHOR CONTRIBUTIONS

AMS and MA—designed the research. AMS, MA, SBS, FFA, OAA, IMA and KMA—performed the research. HMH—provided help and advice on the design of the study. AMS and HMH—analyzed the data. AMS, HMH, MA, SBS, FFA, OAA, IMA and KMA—wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Consent was obtained from the participants before enrolling them in the study. Ethical approval was obtained from the Institutional Review Board and the College of Dentistry Research Center at King Saud University (IRB research project No E-21-6290).

ACKNOWLEDGMENT

The authors extend their appreciation to the Deputyship for Research & Innovation, Ministry of Education in Saudi Arabia for funding this research work through the project no. (IFKSUOR3-246-1). The authors would also like to thank the faculty members for their valuable time filling out our questionnaire.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at <https://oss.jocpd.com/files/article/1720320842777149440/attachment/Supplementary%20material.docx>.

REFERENCES

- [1] Cheng L, Zhang L, Yue L, Ling J, Fan M, Yang D, *et al.* Expert consensus on dental caries management. *International Journal of Oral Science*. 2022; 14: 17.
- [2] Alshammari FR, Alamri H, Aljohani M, Sabbah W, O'Malley L, Glenn AM. Dental caries in Saudi Arabia: a systematic review. *Journal of Taibah University Medical Sciences*. 2021; 16: 643–656.
- [3] Al-Shahrani N, Al-Amri A, Hegazi F, Al-Rowis K, Al-Madani A, Hassan KS. The prevalence of premature loss of primary teeth and its impact on malocclusion in the Eastern Province of Saudi Arabia. *Acta Odontologica Scandinavica*. 2015; 73: 544–549.
- [4] Duncan HF. Present status and future directions—vital pulp treatment and pulp preservation strategies. *International Endodontic Journal*. 2022; 55: 497–511.
- [5] Svante Twetman, Avijit Banerjee. *Caries risk assessment. Risk assessment in oral health: a concise guide for clinical application* (pp. 89–100). Springer: Cham. 2020.
- [6] AAPD. *Pulp therapy for primary and immature permanent teeth. The Reference Manual of Pediatric Dentistry* (pp. 415–423). American Academy of Pediatric Dentistry: Chicago, Ill. 2020.
- [7] Dhar V, Marghalani AA, Crystal YO, Kumar A, Ritwik P, Tulunoglu O, *et al.* Use of vital pulp therapies in primary teeth with deep caries lesions. *Pediatric Dentistry Journal*. 2017; 39: 146–159.
- [8] Smaïl-Faugeron V, Glenn AM, Courson F, Durieux P, Muller-Bolla M, Chabouis H. Pulp treatment for extensive decay in primary teeth. *Cochrane Database of Systematic Reviews*. 2018; 5: CD003220.
- [9] Bossù M, Iaculli F, Di Giorgio G, Salucci A, Polimeni A, Di Carlo S. Different pulp dressing materials for the pulpotomy of primary teeth: a systematic review of the literature. *Journal of Clinical Medicine*. 2020; 9: 838.
- [10] Sahin N, Saygili S, Akcay M. Clinical, radiographic, and histological evaluation of three different pulp-capping materials in indirect pulp treatment of primary teeth: a randomized clinical trial. *Clinical Oral Investigations*. 2021; 25: 3945–3955.
- [11] Gizani S, Seremidi K, Stratigaki E, Tong HJ, Duggal M, Kloukos D. Vital pulp therapy in primary teeth with deep caries: an umbrella review. *Pediatric Dentistry Journal*. 2021; 43: 426–437.
- [12] Dunston B, Coll JA. A survey of primary tooth pulp therapy as taught in US dental schools and practiced by diplomates of the American Board of Pediatric Dentistry. *Pediatric Dentistry Journal*. 2008; 30: 42–48.
- [13] Monteiro J, Ni Chaollai A, Duggal M. The teaching of management of the pulp in primary molars across Europe. *European Archives of Paediatric Dentistry*. 2017; 18: 203–208.
- [14] Ni Chaollai A, Monteiro J, Duggal MS. The teaching of management of the pulp in primary molars in Europe: a preliminary investigation in Ireland and the UK. *European Archives of Paediatric Dentistry*. 2009; 10: 98–103.
- [15] Hincapié S, Fuks A, Mora I, Bautista G, Socarras F. Teaching and practical guidelines in pulp therapy in primary teeth in Colombia—South America. *International Journal of Paediatric Dentistry*. 2015; 25: 87–92.
- [16] Walker LA, Sanders BJ, Jones JE, Williamson CA, Dean JA, Legan JJ, *et al.* Current trends in pulp therapy: a survey analyzing pulpotomy techniques taught in pediatric dental residency programs. *Journal of Dentistry for Children*. 2013; 80: 31–35.
- [17] von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, STROBE Initiative. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Journal of Clinical Epidemiology*. 2008; 61:344–349.
- [18] Bergoli AD, Primosch RE, de Araujo FB, Ardenghi TM, Casagrande L. Pulp Therapy in primary teeth—profile of teaching in Brazilian Dental Schools. *Journal of Clinical Pediatric Dentistry*. 2010; 35: 191–195.
- [19] Ali H, Raslan N. Direct pulp capping (DPC) in primary molars using (3Mix-MP) and the characteristics of the carious lesion as predictor factors for its success: a randomized controlled trial. *European Archives of Paediatric Dentistry*. 2021; 22: 633–642.
- [20] Chatzidimitriou K, Vadiakas G, Koletsi D. Direct pulp capping in asymptomatic carious primary molars using three different pulp capping materials: a prospective clinical trial. *European Archives of Paediatric Dentistry*. 2022; 23: 803–811.
- [21] Dimitraki D, Papageorgiou SN, Kotsanos N. Direct pulp capping versus pulpotomy with MTA for carious primary molars: a randomized clinical trial. *European Archives of Paediatric Dentistry*. 2019; 20: 431–440.
- [22] Garrocho-Rangel A, Esparza-Villalpando V, Pozos-Guillen A. Outcomes of direct pulp capping in vital primary teeth with cariously and non-cariously exposed pulp: a systematic review. *International Journal of Paediatric Dentistry*. 2020; 30: 536–546.
- [23] Pulikkotil SJ, Veetil SK, Vineet Dhar BD. Effectiveness of formocresol and ferric sulfate as pulpotomy material in primary molars: a systematic review and meta-analysis with trial sequential analysis of randomized clinical trials. *Quintessence International*. 2019; 50: 2–15.
- [24] Tseveenjav B, Furuholm J, Mulic A, Valen H, Maisala T, Turunen S, *et al.* Survival of primary molars with pulpotomy interventions: public oral health practice-based study in Helsinki. *Acta Odontologica Scandinavica*. 2021; 79: 636–641.
- [25] Roberts JF, Attari N, Sherriff M. The survival of resin modified glass ionomer and stainless steel crown restorations in primary molars, placed in a specialist paediatric dental practice. *British Dental Journal*. 2005; 198: 427–431.

How to cite this article: Ayman M. Sulimany, Mannaa Aldowsari, Saad Bin Saleh, Faisal F. Almajhdi, Omar A. Al Ajlan, Ibrahim M. ALSayyari, *et al.* Primary tooth vital pulp therapy techniques taught in dental schools in Saudi Arabia: a cross-sectional study. *Journal of Clinical Pediatric Dentistry*. 2023; 47(6): 86-93. doi: 10.22514/jocpd.2023.082.