

RESEARCH

Open Access



Knowledge and attitudes of dental students and interns on minimally invasive dentistry for pediatric dentistry at King Saud University

Zain Hafiz^{1*}, Majdah Alhomaidhi¹, Reema Almutairi², Alaa Alharbi², Lama Alshahrani² and Shaima Alzahrani²

Abstract

Background Minimally invasive dentistry (MID) is a conservative approach focusing on early diagnosis and minimally invasive procedures to prevent the progression of carious lesions. The aim of the study was to assess the knowledge of minimally invasive dentistry among dental students and interns and encourage them to improve their attitudes towards minimally invasive pediatric dentistry (MIPD).

Methods A validated questionnaire used to test the knowledge level of 4th, 5th years dental students and interns was distributed prior to an interventional lecture, followed by an educational lecture on the minimally invasive techniques used in pediatric dentistry and later a post-intervention questionnaire distributed to the dental students and interns.

Results Almost 74% from the 183 study participants reported that they were aware of the term MIPD, 73.8% of them had responded positively, and a higher proportion 65.6% of them knew about this through lectures. The study subject's knowledge about MIPD was assessed before they attended the lecture on this topic and after the lecture in multiple responses, where the proportion for different procedures had increased from pre-intervention to post-intervention.

Conclusion It can be concluded that the dental students and interns have an acceptable amount of knowledge on MIPD. However, there is a lack of knowledge on when to use these techniques and how to apply them.

Keywords Pediatric dentistry, Dental students, Early diagnosis, Dental caries, Minimally invasive dentistry

Introduction

Dental caries is a widespread non-communicable disease that has an impact on a child's functional, social, and psychological well-being [1]. For a long time, dental caries management used to concentrate on invasive restorations or extractions; instead, a minimally invasive approach is recommended nowadays [2, 3].

The concept of preventive dentistry was not adopted before the late 1970s; the carious lesion was treated by initial restorative treatment in its early stages because the concept of arresting caries wasn't supported yet [4]. However, in early 1980s, a non-operative and more

*Correspondence:

Zain Hafiz
zhafiz1@ksu.edu.sa

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

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



© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

preventive approach was introduced after discovering the slow progression of caries [5]. As a result, it is no longer advisable to begin restorative treatment early in the carious process and to remove all carious tissues until caries-resistant areas are reached [3, 6].

Prevention in childhood and monitoring the oral health of the child include focusing on education of care givers who are responsible on educating parents based on the knowledge they acquire during their training years [7]. Minimally invasive dentistry (MID) is a conservative approach focusing on early diagnosis and minimally invasive procedures to prevent and arrest the progression of carious lesions [8]. The shift towards minimally invasive dentistry first appeared in Sweden, where studies showed a movement towards a conservative approach [9]. A study by Anusavice indicated the need for restorative treatment only if: (a) coronal caries are extending into the dentin; (b) there is presence of pulpal symptoms; and (c) patients with aesthetic, functional, or periodontal problems [10]. Moreover, Mount and Ngo discouraged using restorative treatment in cases of approximal caries. They believed that the involvement of dentin when it appears in a bitewing radiograph doesn't necessarily mean the lesion is cavitated [11]. Preventive measures with a minimally invasive approach can improve patients' oral health in the long term by determining caries risk factors and early caries detection [12]. Upon following this approach, the intact dental structures will be preserved, the carious lesions will be arrested, and hard dental tissues will be remineralized [13].

Furthermore, minimally invasive treatment procedures involve: fluoride application (FA), fissure sealants (FS), resin infiltration (RI), silver diamine fluoride (SDF), Hall technique (HT), and atraumatic restorative treatment (ART). The appropriate treatment is selected according to the lesion's activity, stage, and location [14].

Fluoride vehicles, such as fluoridated gels, rinses, and varnish, can be used to treat non-cavitated carious lesions [15]. While cavitated lesions can be treated with therapeutic sealants, SDF, RI, HT, and ART [14, 16–18]. Studies by Chestnutt, Ying Lam and Turska-Szybka proved the efficacy of fluoride varnishes (FV) in the prevention of early carious lesions development [19–21]. The systematic review by Cabalén concluded that sealants, fluoride gels and varnishes are effective treatments for preventing carious lesions and arresting them early [22]. Applying sealants in non-cavitated occlusal lesions reduces the nutrient availability of microbial growth, which will prevent lesion progression by up to 70% [23, 24].

Silver diamine fluoride (SDF) is a minimally invasive treatment method approved by The U.S. Food and Drug Administration (FDA) since 2014. This treatment method involves the placement of SDF to the carious lesion to

arrest the caries progression. It is indicated in several cases, including individuals with high caries risk/uncooperative patients, active carious lesions without pulp involvement, dentin hypersensitivity, and molar incisor hypomineralisation (MIH). The side effects include black staining of the carious lesion, metallic taste, pulpal irritation, and soft tissue irritation [25]. In addition, based on the studies by Dorri and Faghihian, resin infiltration has shown its efficacy in cases of non-cavitated proximal caries in primary and permanent teeth. Because resin fills in the porosity of the enamel and protects the surface from dental biofilm penetration, resin infiltration stops the carious lesion from progressing [26, 27].

Hall technique is a method that was introduced by a general dentist, Dr. Norna Hall. This method suggests the placement of fitting metal ceramic crowns using GIC without caries removal or tooth preparation. The principle of this technique is to isolate the carious lesion from the oral flora and, therefore, arrest the caries progression. It can be done without using local anesthesia, and it helps with non-compliant patients by providing a less traumatic experience [28]. Furthermore, the atraumatic restorative treatment (ART) approach is performed by removing the affected dentin by hand instruments without local anesthesia administration, and the prepared cavity is restored with glass-ionomer cement. This is in contrast to the traditional approach, which using rotary instruments and administration of local anesthesia. This approach may be used with very young patients, in primary care clinics, and with anxious children with limited cooperation [29, 30]. The application of these procedures depends on the knowledge of the practitioner, their ability to perform it, and their decision to perform the intervention based on evidence.

In Saudi Arabia, a study was conducted to assess the knowledge and attitude among general practitioners of minimally invasive dentistry. It has been found that 60% of participants did not receive education on this topic. However, general practitioners who received education showed better knowledge and attitude in applying minimally invasive methods [31]. However, there is no evidence on the knowledge of the undergraduate students and dental interns in Saudi Arabia on minimally invasive approaches and how effectively they can indicate this approach for carious lesions in the primary dentition. High caries prevalence in Saudi Arabia necessitates the need for more preventive measures rather than early restorative intervention. Up to now, no studies have assessed the knowledge and practice of minimally invasive procedures in pediatric dentistry among dental students and interns. Therefore, this study will assess the knowledge of minimally invasive dentistry among dental students and interns and encourage them to improve

their attitudes towards minimally invasive pediatric dentistry (MIPD).

Methods

Study population

An interventional, non-randomized (questionnaire-based) study was conducted among fourth and fifth year dental students as well as interns at King Saud University. The total sample size was calculated based on the data obtained in a previous pilot study in which the formula for analysis of variance was applied in G*Power statistical software version 3.1.9.7 considering a significance level (α) = 0.05 and statistical power ($1 - \beta$) = 0.90 and it was estimated that a minimum sample size of 103 would be necessary to assess the knowledge of dental students and interns of minimally invasive techniques used in pediatric dentistry, including diagnosis and treatment.

Data collection

A survey was constructed by two faculty members, a pediatric consultant and a restorative consultant from the Pediatric Dentistry department and Restorative Dentistry Department. The survey then validated by a consultant specialized in dental materials and an expert statistician. Additionally, to assure understanding and clarity of the questions, a random sample of fourth- fifth-years dental students and dental interns were selected before administration. The fourth- and fifth-years dental students and dental interns who were involved in the pilot sample were not included in the study. They survey was used to test the knowledge level of fourth- and fifth-years dental students as well as dental interns which was distributed prior to the interventional lecture (Annex 1), followed by a 15–20 min educational lecture on the minimally invasive techniques including (brief introduction and definition of each technique, advantages, disadvantages, indications and contraindications) that are used in pediatric dentistry, which was distributed prior to a lecture on the non-invasive techniques used in pediatric dentistry prepared by a consultant of the specialty. The

dental students and interns were not given any slides or information prior to the pre-intervention questionnaire. Later, after two weeks the post-questionnaire was distributed. The questionnaire was divided into five main sections. The first section contains questions about the demographic data (e.g. age, gender, educational level). The second and third parts measure participants's awareness and knowledge on the minimally invasive pediatric dentistry (MIPD). The fourth part assesses the participants' attitudes toward MIPD. The fifth part includes case scenario questions assessing clinical decision behavior toward MIPD.

Ethical consideration

The first page of the questionnaire will explain the purpose of the study and obtain consent from participants. To maintain confidentiality, names were not required, and each student identified by a number specified for him/her for the pre/post questionnaire. The data was collected through a secure link and handled carefully during the collection and analysis stages. Only team members could access the questionnaire data, and once all responses have been collected, the data was securely saved. Ethical approval (No. E-23-8092) was obtained from the Institutional Review Board (IRB) and the College of Dentistry Research Center (CDRC) at King Saud University, Riyadh, Saudi Arabia.

Data analysis

Data were analyzed using IBM SPSS Statistical software for Windows version 26.0 (IBM Corp., Armonk, N.Y., USA). Descriptive statistics (frequencies and percentages) were used to describe the categorical variables. The marginal homogeneity test was used to compare the categorical data responses between pre and post-intervention periods. A p-value of < 0.05 was used to report the statistical significance of the results.

Results

Out of 258 fourth and fifth years dental students and dental intern, 183 subjects participated in this study, the 75 subjects who didn't participate or didn't complete the pre-intervention and post-intervention questionnaire were distributed as follow: fourth year dental student (2 students out of 60), fifth year dental students (40 students out of 75), and dental interns (33 out of 123 interns). Almost 97% of the participants were in the age group of 21 to 25 years, 55.7% were males, and 49.2% were in their internship (Table 1).

Regarding the awareness of the term minimally invasive pediatric dentistry (MIPD), 73.8% of them had responded positively, and a higher proportion 65.6% of them had come to know about this through lectures in dental school, followed by faculty/friends (44.2%) and

Table 1 Distribution of demographic characteristics of study participants ($n = 183$)

Characteristics	No. (%)
Age groups	
21–25	177(96.7)
26–27	6(3.3)
Gender	
Male	102(55.7)
Female	81(44.3)
Education level	
4th year	58(31.7)
5th year	35(19.1)
Intern	90(49.2)

online search/social media (30.5%) when they have asked to respond to different options as multiple responses. Most of them (91.8%) had learned now about MIPD during their 3rd, 4th, and 5th at dental school (Table 2).

The study participant's knowledge about MIPD was assessed before they attended the lecture on this topic and after the lecture in multiple responses, where the proportion for different procedures had increased from pre-intervention to post-intervention. For the ART procedure to be considered as MIPD, 59.6% of them responded during pre-intervention whereas 87.4% during post-intervention, for the FV procedure to be considered as MIPD, 61.7% during pre-intervention whereas 72.7% during post-intervention. Similarly, for the other four procedures (SDF, HT, PFS, the proportion of responses also increased from pre-intervention to post-intervention. However, for one of the options, 'SE & SW,' the proportion of responses decreased from pre-intervention (39%) to post-intervention (9.3%). For another item of knowledge (MIPD is usually indicated in) about MIPD, there is a statistically significant difference in the proportion of responses between pre-intervention and post-intervention, where 51.4% of them responded as 'pre-operative children, anxious patients, and individuals with special health care need (SHCN) or limited access to care during pre-intervention where 70.5% of them responded to the similar option during post-intervention. Similar differences in proportions between pre- and post-intervention responses were observed for the other two options. These differences in proportions are highly statistically significant ($p < 0.0001$) (Table 3).

The comparison of study participants' attitude responses towards MIPD between pre and post-intervention shows a statistically significant difference in responses between pre and post for one attitude statement (I know the indications and contraindications regarding each MIPD technique) out of 6 attitude statements. The proportions of the 5-point scale (strongly disagree, disagree, uncertain, agree, and strongly agree) at pre-intervention (10.9%, 21.9%, 45.4%, 14.8%, 7.15) had changed to post-intervention (5.5%, 2.2%, 7.7%, 36.1% & 48.6%) which is highly statistically significant ($p < 0.0001$). There is no statistically significant difference in the responses between pre-and post for the other five attitude statements (Table 4).

The comparison of the study participants' clinical decision behavior responses towards MIPD based on 6 Case Scenarios between pre and post-time points of intervention (lecture on MIPD) shows a statistically significant difference in the proportion of responses to the correct answer for three scenarios. For the first scenario, the proportion of correct responses to the option (Hall technique) out of 4 options was 27.9% at pre-intervention, whereas it increased to 72.1% in the post-intervention

Table 2 Distribution of responses towards awareness on the minimally invasive pediatric dentistry

Items of awareness	No. (%)
Are you aware of the term minimally invasive pediatric dentistry (MIPD)?	
Yes	135(73.8)
No	48(26.2)
If Yes, how did you know about MIPD? *	
Books/Journals	27(17.5)
Conferences/Conventions	11(7.1)
Seminars/Webinars	12(7.8)
Online Search/Social media	47(30.5)
Faculty/Friends	68(44.2)
Lectures in dental school	101(65.6)
If yes, when did you learn about MIPD during your dental school studies? (n = 134)	
3rd year	35(26.1)
4th year	55(41.0)
5th year	33(24.6)
Internship	11(8.2)

*Multiple responses

Table 3 Comparison of study participants' responses towards their knowledge about MIPD between pre and post-time points of intervention (lecture on MIPD)

Items of knowledge	Responses		p-value
	Pre-inter- vention No. %	Post- intervention No. %	
Which among the following procedures are considered as MIPD*			
Atraumatic restorative treatment (ART)	109(59.6)	160(87.4)	--
Fluoride varnish (FV)	113(61.7)	133(72.7)	
Silver Diamine Fluoride (SDF)	98(53.6)	163(89.1)	
Hall technique (HT)	42(23.0)	151(82.5)	
Pit and fissure sealant (PFS)	116(63.4)	144(78.7)	
Resin infiltration (RI)	86(47.0)	149(81.4)	
Selective caries excavation (SE) and stepwise caries excavation (SW)	72(39.0)	17(9.3)	
MIPD is usually indicated in:			
Pre-cooperative children, anxious patients, and individuals with special health care needs (SHCN) or limited access to care	94(51.4)	129(70.5)	<0.0001**
Young cooperative children	21(11.5)	13(7.1)	
All pediatric dental patients	61(33.3)	39(21.3)	
Only with SHCN patients	7(3.8)	2(1.1)	

*Multiple responses; ** By using the Marginal Homogeneity test

period, for the second scenario, the proportion of correct responses to the option (Silver Diamine Fluoride -SDF-) out of 4 options, was 32.2% at pre-intervention, whereas it has increased to 63.9% at post-intervention period, for the fifth scenario, the proportion of correct response to the option (ART, SDF, and HT) out of 4 options, was

Table 4 Comparison of study participants' attitude responses towards MIPD between pre and post-time points of intervention (lecture on MIPD)

Attitude statements	Responses		p-value*
	Pre-intervention No. %	Post-intervention No. %	
Do you think fluoride application is an effective way of preventing dental caries?			
Strongly Disagree	13(7.1)	11(6.0)	0.145
Disagree	2(1.1)	2(1.1)	
Uncertain	6(3.3)	2(1.1)	
Agree	49(26.8)	38(20.8)	
Strongly Agree	113(61.7)	130(71.0)	
Do you think G. V. Black's "extension for prevention" is relevant for initial caries?			
Strongly Disagree	51(27.9)	67(36.6)	0.196
Disagree	38(20.8)	41(22.4)	
Uncertain	42(23.0)	26(14.2)	
Agree	34(18.6)	27(14.8)	
Strongly Agree	18(9.8)	22(12.0)	
Do you think adhesive restorative materials have helped in preserving tooth structure?			
Strongly Disagree	13(7.1)	10(5.5)	0.269
Disagree	4(2.2)	5(2.7)	
Uncertain	13(7.1)	5(2.7)	
Agree	47(25.7)	48(26.2)	
Strongly Agree	106(57.9)	115(62.8)	
Do you think caries risk assessment should be carried out for all patients?			
Strongly Disagree	11(6.0)	9(4.9)	0.105
Disagree	8(4.4)	7(3.8)	
Uncertain	15(8.2)	5(2.7)	
Agree	54(29.5)	51(27.9)	
Strongly Agree	95(51.9)	111(60.7)	
Do you think the application of pit and fissure sealants is for the larger benefit to society?			
Strongly Disagree	13(7.1)	10(5.5)	0.198
Disagree	3(1.6)	5(2.7)	
Uncertain	11(6.0)	7(3.8)	
Agree	55(30.1)	42(23.0)	
Strongly Agree	101(55.2)	119(65.0)	
I know the indications and contraindications regarding each MIPD technique			
Strongly Disagree	20(10.9)	10(5.5)	< 0.0001
Disagree	40(21.9)	4(2.2)	
Uncertain	83(45.4)	14(7.7)	
Agree	27(14.8)	66(36.1)	
Strongly Agree	13(7.1)	89(48.6)	

*By using Wilcoxon sign rank test

61.7% at pre-intervention, whereas it has increased to 74.3% at post-intervention period which indicates highly statistically significant difference in the correct responses for these three scenarios ($p = 0.007$, $p < 0.0001$ & $p = 0.002$). For the fourth scenario, the proportion of correct response to the option (Pulpectomy /Extraction) out of 4 options was 88% at pre-intervention, whereas it decreased to 79.2% in the post-intervention period, and this difference is statistically significant ($p = 0.011$). For the remaining two scenarios, there is no statistically significant difference in the proportion of correct responses to the option (Prophylaxis, topical fluoride, and fissure

sealants for the erupted permanent first molars and resin infiltration) out of 4 options between pre and post-intervention period ($p = 0.088$, $p = 0.241$) (Table 5).

Discussion

Minimally invasive dentistry is a conservative approach to caries management, and the advantages of such techniques are that they are easy, affordable, and have a painless application while preserving tooth structures [32].

This study aimed to promote and improve attitudes toward minimally invasive dentistry by evaluating dental students' and interns' understanding of minimally

Table 5 Comparison of study participants' clinical decision behavior responses towards MIPD based on case scenarios between pre and post-time points of intervention (lecture on MIPD)

Clinical Scenarios	Responses		p-value ¥
	Pre-inter- vention No. %	Post- intervention No. %	
1. A 5-year-old healthy child with uncooperative behavior. The child is examined and is classified as high caries risk. Referred to restore a single carious tooth #85 with cl I (O) and cl II (D) caries, which is not pulpally involved and doesn't have signs and symptoms. Choose the most appropriate treatment for this case:			
Cl I (O) + Cl II (D) composite	41(22.4)	15(8.2)	0.007
Cl I (O) + Cl II (D) GIC	40(21.9)	14(7.7)	
Hall technique*	51(27.9)	132(72.1)	
Conventional technique for placing stainless steel crown	51(27.9)	22(12.0)	
2. A 4-year-old child diagnosed with attention deficit hyperactivity disorder (ADHD) can't stop moving while on the dental chair. The child is examined and is classified as high caries risk. His mother complains of the cavity on the upper left tooth. Examination shows #64 has cl V (facial) caries, which is not pulpally involved and has no signs or symptoms. Choose the most appropriate treatment for this case:			
Cl V composite restoration	14(7.7)	12(6.6)	< 0.0001
Cl V GIC restoration	98(53.6)	49(26.8)	
Conventional technique for placing stainless steel crown	12(6.6)	5(2.7)	
Silver Diamine Fluoride SDF*	59(32.2)	117(63.9)	
3. A 10-year-old child diagnosed with autism. The child is examined and is classified as moderate caries risk. The mother brought her child for the regular recall visit. The child has no new carious lesions. Choose the most appropriate approach for this case:			
Prophylaxis, topical fluoride, and fissure sealants for the erupted permanent first molars*	133(72.7)	145(79.2)	0.088
Prophylaxis, sandblasting, then applying fissure sealants for the erupted permanent first molars	13(7.1)	15(8.2)	
Prophylaxis, enameloplasty, and fissure sealants for the erupted permanent first molars	14(7.7)	7(3.8)	
No procedure is needed, and the patient will be booked for a recall visit after three months	23(12.6)	16(8.7)	
4. A 6-year-old healthy but anxious child. The child is examined and is classified as high caries risk. Referred to restore #65. The mother reported that the child had pain and abscess related to this tooth two months ago and hasn't complained of this tooth since then. Choose the most appropriate treatment for this case:			
Pulpectomy/Extraction*	161(88.0)	145(79.2)	0.011
SDF	10(5.5)	9(4.9)	
Hall Technique	6(3.3)	17(9.3)	
ART	6(3.3)	12(6.6)	
5. A 4-year-old healthy child with uncooperative behavior. The child is examined and is classified as high caries risk and referred to be treated under general anesthesia. Her mother complained of the long waiting time till the operation day, and she is concerned that the cavities will progress more, leading to pain, and that the affected teeth will get more destructed. After careful case evaluation, the most appropriate approach will be:			
ART, SDF, and Hall technique*	113(61.7)	136(74.3)	0.002
Extraction of the pulp ally involved teeth	36(19.7)	27(14.8)	
ART	20(10.9)	18(9.8)	
Application of topical fluoride gel	14(7.7)	2(1.1)	
6. A 12-year-old healthy child. The child complains of white spots on her frontal middle teeth. Examination showed that the child has mild molar-incisor hypo mineralization (MIH). The most appropriate approach in this case is:			
Composite restoration	13(7.1)	6(3.3)	0.241
Resin infiltration*	160(87.4)	174(95.1)	
Composite veneer	--	2(1.1)	
Enameloplasty	10(5.5)	1(0.5)	

*Correct answer; ¥ By using the Marginal homogeneity test

invasive pediatric dentistry (MIPD), using a pre-questionnaire, a post-questionnaire, and an instructive lecture in the College of Dentistry, King Saud University, Saudi Arabia. The number of study subjects was 183, and no difference was noted between male and female students. Almost 74% of the study participants had responded

positively regarding minimally invasive dentistry, and a higher proportion 65.6% of them had come to know about it through lectures in dental school, followed by faculty/friends (44.2%), and most of them (91.8%) had learned about (MIPD) during their undergraduate studies. Similarly, 65.7% of respondents in a study conducted

by Al Harbi agreed to have knowledge of (minimally invasive dentistry) MID during their undergraduate courses, in which lectures proved to be the primary source of knowledge for 48% of the respondents [33].

In contrast, Dixit et al. (2023) showed that only 42.2% of the respondents had received (MID) training during their undergraduate or internship years, and most of that training (45.2%) came through lectures [34]. In a study done in 2016 among general practitioners in Riyadh/Kharj on 161 participants, 59.01% of them did not receive education about MIPD during their undergraduate training [31].

In comparison to the results obtained in the current study, it is shown that there is an improvement and an updated curriculum in the undergraduate studies about the (MIPD) in the College of Dentistry at King Saud University.

Moreover, an assessment of the knowledge about ART, FV, SDF, HT, PFS, and RI procedures to be considered as MIPD was done, and the proportion of responses had increased positively from pre-intervention to post-intervention. However, while PFS is taught theoretically and clinically widely amongst dental schools, the other techniques, SDF, HT, and RI, were not incorporated sufficiently into the clinical practice nor theoretically in the undergraduate studies. According to a study in the eastern province of Saudi Arabia, 57% of students were unaware of the HT [35]. Whereas in the same study, 29.6% of students were aware of SDF, with undergraduate studies contributing significantly (33.3%). On the contrary, Al Shamrani et al. (2020) assessed the awareness of the use of SDF among 252 students and interns; it was reported that more than half of the respondents (54.8%) did not know or read about anything about SDF [36]. A cross-sectional study was done by Moradi et al. (2021) on 40 participants, two of whom were only taught about HT and RI [37]. Furthermore, in the current study, there was a statistically significant difference in the proportion of responses between pre and post-intervention (51.4%, 70.5%) in using MIPD as a technique indicated with pre-operative children, anxious patients, and individuals with special health care need (SHCN) or limited access to dental care.

Minimally invasive pediatric dentistry has been shown to be effective in managing anxious patients, patients with limited access to dental care, and cases in which general anesthesia is not preferred due to cost or parental preference [38]. Ladewig et al. (2018) reported a significant difference in anxiety levels comparing rotary instrument treatments with and without local anesthetic, which favors the use of MIPD when indicated [39]. Moreover, the participants' attitudes about MIPD showed during the pre-and post-intervention periods revealed statistical significance when their knowledge was assessed about

the indications and contraindications regarding each MIPD technique, in which 45.4% responded uncertain in the pre-intervention while 36.1% and 48.6% responded agree and strongly agree in the post-intervention questionnaire. This can be explained by the fact that the attitude toward MIPD can be improved by education and providing dental students and interns with the proper training.

Gaurav Gupta et al. (2014) conducted a study on interns who showed a good attitude and sufficient understanding of (MID). However, they didn't practice (MID) much, and their behavior toward it was negative [40]. Kaidonis et al. (2013) suggested that students' selection of materials or concepts for their future activities is also greatly influenced by the views of faculty members and institutional policies [41]. In addition, the improvement shown in dental students' and interns' attitudes toward MIPD in the current study after providing educational lecture reinforces the need to update the undergraduate curriculum regarding each technique of MIPD and incorporate it into the clinical practice. In this study, the survey included six validated clinical scenarios, and there was a statistically significant difference in the proportion of accurate answers for three of the six clinical scenarios. However, in the fourth scenario, the proportion of correct response to the option (Pulpectomy /Extraction) out of 4 options was 88% at pre-intervention, whereas it decreased to 79.2% at post-intervention period, and this difference is statistically significant ($p=0.011$). Characterizing the patient as anxious within the presented scenario may lead the participants to infer that extraction and pulpectomy procedures were deemed impractical in that context. Furthermore, the limited duration of the lecture amidst the students' demanding schedules might have played a role in fostering misunderstandings. To improve decision-making in the future, ensure thorough communication and discussion among the instructor and students. Emphasize the importance of considering all options and their implications before choosing a treatment plan. Encourage a collaborative approach where different perspectives are taken into account, minimizing the risk of selecting a conservative option when traditional invasive options are indicated. Continuous training and updates on the latest evidence-based practices can also contribute to better decision-making. Moreover, Cunningham et al. reported that dentist's clinical decision making for the treatment of caries vary significantly [42]. For example, the ART approach, has been known as an economical and effective procedure for treating caries, in vulnerable population [43]. Nadar et al. reported that the use of ART usually depends on social and environmental factors, such as: child's age, socioeconomic status, and the child's cooperation level [44]. Thus, choosing the appropriate procedure is usually based on multiple

factors in which students and dental interns must be aware of when treating pediatric dental patients.

Additionally, research has been conducted by the Brazilian Ministry of Education, which aimed to assess the integration of curricular innovations across 208 dental schools in alignment with public health policies. The findings revealed statistically significant distinctions in the delivery of healthcare services to society by students between institutions implementing up-to-date curricular approaches and those adhering to traditional systems. This underscores the potential impact of curricular innovation on shaping the effectiveness of dental education in addressing societal health needs [45]. The limitations of this study may include: (1) the small sample size that would affect the generalizability of the findings. A larger sample size that covers multiple dental colleges in Saudi Arabia is recommended in future studies; (2) The limited time available to deliver a more detailed lecture about MIPD to the dental students and interns due to their schedules, which may lead to an incomplete understanding of the topic by some of the participants.

Conclusion

It can be concluded that the dental students and interns have an acceptable amount of knowledge on (MIPD). However, there is a lack of knowledge on when to use these techniques and how to apply them, suggesting the need to improve the undergraduate curriculum and improve the knowledge and clinical training on MIPD so it can be implied correctly when indicated.

Acknowledgements

Not applicable.

Author contributions

Z.H. conceptualization, investigation, methodology, writing—original draft, writing—review, and editing M.H. investigation, methodology, writing—original draft, writing—review R.M. investigation, data collection, writing the original draft A.H. investigation, data collection, writing the original draft L.S. investigation, data collection, writing the original draft S.Z. investigation, data collection, writing the original draft.

Funding

Not applicable.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Ethical approval (No. E-23-8092) was obtained from the Institutional Review Board (IRB) and the College of Dentistry Research Center (CDRC) at King Saud University, Riyadh, Saudi Arabia. A written informed consent to participate was obtained from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 18 June 2024 / Accepted: 1 May 2025

Published online: 14 May 2025

References

1. Kassebaum NJ, Bernabé E, Dahiya M, Bhandari B, Murray C, Marcenes W. Global burden of untreated caries: a systematic review and metaregression. *J Dent Res*. 2015;94(5):650–8.
2. Calache H, Hopcraft MS, Martin JM. Minimum intervention dentistry—a new horizon in public oral health care. *Aust Dent J*. 2013;58:17–25.
3. Schwendicke F, Splieth C, Breschi L, Banerjee A, Fontana M, Paris S, Manton DJ. When to intervene in the caries process? An expert Delphi consensus statement. *Clin Oral Invest*. 2019;23:3691–703.
4. Vidnes-Kopperud S, Tveit AB, Espelid I. Changes in the treatment concept for approximal caries from 1983 to 2009 in Norway. *Caries Res*. 2011;45(2):113–20.
5. Pitts NB. Monitoring of caries progression in permanent and primary posterior approximal enamel by bitewing radiography A review. *Commun Dent Oral Epidemiol*. 1983;11(4):228–35.
6. Laske M, Opdam NJ, Bronkhorst EM, Braspenning JC, van der Sanden WJ, Huysmans MCD, Bruers JJ. Minimally invasive intervention for primary caries lesions: are dentists implementing this concept? *Caries Res*. 2019;53(2):204–16.
7. Pranono N, Zumbo G, Tranquilli M, Stamegna L, Zara F, Vozza I. Oral hygiene habits and use of fluoride in developmental age: role of parents and impact on their children. *Biomed Res Int*. 2022;2022:6779165.
8. Drachev SN, Galieva AS, Yushmanova TN, Polivanaya EA, Stangvaltaite-Mouhat L, Al-Mahdi R, Al-Harooni M. Restorative treatment decisions for carious lesions: do Russian dentists and dental students apply minimal intervention dentistry? *BMC Oral Health*. 2021;21:1–12.
9. Pakdaman A, Evans RW, Howe E. Dental students' knowledge and perceptions of non-invasive dental caries management. *Aust Dent J*. 2010;55(1):28–36.
10. Anusavice KJ, editor. (1989). *Quality Evaluation of Dental Restorations: Criteria for Placement and Replacement: Proceedings of the International Symposium on Criteria for Placement and Replacement of Dental Restorations*, Lake Buena Vista, Florida, October 19–21, 1987. Quintessence Publishing (IL).
11. Mount GJ, Ngo H. (2000). *Minimal intervention: early lesions*. Quintessence Int, 31(8).
12. Walsh LJ, Brostek AM. Minimum intervention dentistry principles and objectives. *Aust Dent J*. 2013;58:3–16.
13. Innes NP, Manton DJ. Minimum intervention children's dentistry—the starting point for a lifetime of oral health. *Br Dent J*. 2017;223(3):205–13.
14. Pozos-Guillén A, Molina G, Soviero V, Arthur RA, Chavarria-Bolaños D, Acevedo AM. (2021). Management of dental caries lesions in Latin American and Caribbean countries. *Brazilian Oral Res*, 35, e055.
15. Gruythuysen RJ. Non-restorative cavity treatment: should this be the treatment of choice? Reflections of a teacher in paediatric dentistry. *Dent Update*. 2019;46(3):220–8.
16. Cagetti MG, Angelino E. Could SARS-CoV-2 burst the use of Non-Invasive and minimally invasive treatments in paediatric dentistry? *Int J Pediatr Dent*. 2021;31(1):27.
17. Splieth C, Banerjee A, Bottenberg P, Breschi L, Campus G, Kim R, E... Doméjean, S. (2020). How to Intervene in the Caries Process in Children: A Joint ORCA and EFCD Expert Delphi Consensus Statement: practice guideline. *Caries research*. Basel:Karger, 2020, vol. 54, no. 4.
18. Sampaio, F. C., Bönecker, M., Paiva, S. M., Martignon, S., Ricomini Filho, A. P., Pozos-Guillén, A.,... Pitts, N. (2021). Dental caries prevalence, prospects, and challenges for Latin America and Caribbean countries: a summary and final recommendations from a Regional Consensus. *Brazilian oral research*, 35, e056.
19. Chestnutt, I. G., Hutchings, S., Playle, R., Morgan-Trimmer, S., Fitzsimmons, D., Awar, N.,... Chadwick, B. L. (2017). Seal or Varnish? A randomised controlled trial to determine the relative cost and effectiveness of pit and fissure sealant and fluoride varnish in preventing dental decay. *Health Technology Assessment (Winchester, England)*, 21(21), 1.
20. Ying Lam PP, Sardana D, Luo W, Ekambaram M, Lee M, Lo GHM, E. C., Yiu Y, C. K. Glass ionomer sealant versus fluoride varnish application to prevent occlusal caries in primary second molars among preschool children: a randomized controlled trial. *Caries Res*. 2021;55(4):322–32.

21. Turska-Szybka A, Gozdowski D, Twetman S, Olczak-Kowalczyk D. Clinical effect of two fluoride varnishes in caries-active preschool children: a randomized controlled trial. *Caries Res.* 2021;55(2):137–43.
22. Cabalén MB, Molina GF, Bono A, Burrow MF. Nonrestorative caries treatment: A systematic review update. *Int Dent J.* 2022;72(6):746–64.
23. Ahovuo-Saloranta A, Forss H, Walsh T, Nordblad A, Mäkelä M, Worthington HV. (2017). Pit and fissure sealants for preventing dental decay in permanent teeth. *Cochrane Database of Systematic Reviews*, (7).
24. Griffin SO, Oong E, Kohn W, Vidakovic B, Gooch BF, CDC Dental Sealant Systematic Review Work Group. The effectiveness of sealants in managing caries lesions. *J Dent Res.* 2008;87(2):169–74.
25. Nuvvula S, Mallineni SK. Silver Diamine fluoride in pediatric dentistry. *J South Asian Association Pediatr Dentistry.* 2019;2(2):74.
26. Dorri M, Dunne SM, Walsh T, Schwendicke F. (2015). Micro-invasive interventions for managing proximal dental decay in primary and permanent teeth. *Cochrane Database of Systematic Reviews*, (11).
27. Faghihian R, Shirani M, Tarrahi MJ, Zakizade M. Efficacy of the resin infiltration technique in preventing initial caries progression: a systematic review and meta-analysis. *Pediatr Dent.* 2019;41(2):88–94.
28. Altoukhi DH, El-Housseiny AA. Hall technique for carious primary molars: a review of the literature. *Dentistry J.* 2020;8(1):11.
29. Holmgren CJ, Roux D, Doméjean S. Minimal intervention dentistry: part 5. Atraumatic restorative treatment (ART)—a minimum intervention and minimally invasive approach for the management of dental caries. *Br Dent J.* 2013;214(1):11–8.
30. De Menezes Abreu DM, Leal SC, Mulder J, Frencken JE. Dental anxiety in 6–7-year-old children treated in accordance with conventional restorative treatment, ART and ultra-conservative treatment protocols. *Acta Odontol Scand.* 2011;69(6):410–6.
31. Shah, A. H., Shedd, F. M., Alharqan, M. S., Khawja, S. G., Vohra, F., Akram, Z.,... Khalil, H. S. (2016). Knowledge and attitude among general dental practitioners towards minimally invasive dentistry in Riyadh and AlKharij. *Journal of clinical and diagnostic research: JCDR*, 10(7), ZC90.
32. Torres PJ, Phan HT, Bojorquez AK, Garcia-Godoy F, Pinzon LM. Minimally invasive techniques used for caries management in dentistry. A review. *J Clin Pediatr Dentistry.* 2021;45(4):224–32.
33. Harbi AHJA, Albarrak MI, Alsweed MA. Knowledge, attitude and practice of minimally invasive dentistry among dental graduates: A Cross-Sectional Survey from Saudi Arabia.
34. Dixit, A., Sindi, A. S., Paul, S., Badiyani, B. K., Kumar, A., Arya, R.,... Obulareddy, V. T. (2023). A study to assess knowledge, attitude, and perception of dental practitioners on minimally invasive dentistry concepts. *Journal of Pharmacy and Bioallied Sciences*, 15(Suppl 2), S993–S996.
35. Ezzeldin, T., Al-Awasi, K. A., Bader, R. M., Alshaikhi, A. Y., Hakami, A. H., Siddiqui, J. A.,... Alsubaie, T. M. (2021). A Study to assess the awareness and use of Silver Diammine Fluoride and Hall Technique among dental professionals and dental students in the Eastern Province. *The Saudi Dental Journal*, 33(8), 1166–1173.
36. Al Shamrani SA, Ashwal A, L. A., Al Kharan MI. Assessment of knowledge about silver Diamine fluoride in Riyadh elm university among students (levels 11 and 12) and interns. *Int J Med Developing Ctries.* 2020;4(11):1831–1831.
37. Moradi S, Sabbagh S, Timms L, Ravaghi V. Teaching minimally invasive interventions in paediatric dentistry: a cross-sectional survey of dental schools in Iran. *BMC Oral Health.* 2021;21:1–7.
38. Lim SN, Kiang L, Manohara R, Tong HJ, Nair R, Hong C, Hu S. Interim therapeutic restoration approach versus treatment under general anaesthesia approach. *Int J Pediatr Dent.* 2017;27(6):551–7.
39. Ladewig NM, Tedesco TK, Gimenez T, Braga MM, Raggio DP. (2018). Patient-reported outcomes associated with different restorative techniques in pediatric dentistry: A systematic review and MTC meta-analysis. *PLoS ONE*, 13(12), e0208437.
40. Gupta G, Shanbhag N, Puranik MP. (2015). Perceptions regarding minimal intervention dentistry among dental interns in India: A cross sectional survey. *Int J Contemp Dent Med Rev*, 2015.
41. Kaidonis JA, Skinner VJ, Lekkas D, Winning TA, Townsend GC. Reorientating dental curricula to reflect a minimally invasive dentistry approach for patient-centred management. *Aust Dent J.* 2013;58:70–5.
42. Cunningham MA, Gaeth GJ, Juang C, et al. Using choice-based conjoint to determine the relative importance of dental benefit plan attributes. *J Dent Educ.* 1999;63(5):391–9.
43. Jobim Jardim J, Henz S, Barbachan E, et al. Restorative treatment decisions in posterior teeth: A systematic review. *Oral Health Prev Dent.* 2017;15(2):107–15.
44. Nadar B, Gv U, Almalki S, Gowdar I. Understanding decision making for the use of atraumatic restorative approach based on non-clinical factors by Indian pedodontists - a conjoint analysis. *F1000Res.* 2024;13:1401.
45. Zilbovicius C, de Araujo ME, Botazzo C, Frias AC, Junqueira SR, Junqueira CR. A paradigm shift in predoctoral dental curricula in Brazil: evaluating the process of change. *J Dent Educ.* 2011;75(4):557–64.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.