An Evaluation on Deep Caries Removal Method and Management Performed by Undergraduate Dental Students: A Malaysia Experience

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Abstract

Objectives The aim of this study was to investigate the current knowledge and attitude of deep caries removal method among dental students in Malaysia.

Materials and Methods A total of 303 students (n = 303) responded to the online questionnaire. The first part of questionnaire was to evaluate the demographic data of the respondents and focused on the technique and management approach used for deep caries lesion. The second part investigated the preferred treatment used for deep caries based on the designated clinical case, while the third part assessed the factors that affected the decision on deep caries management.

Statistical Analysis Independent t-test was used to compare difference between the two groups.

Results Seventy four percent of the students have the knowledge of the different methods of caries removal, while 25.8% were only familiar with complete caries removal. The preferred method for deep caries removal in permanent teeth was partial caries removal (53%). For primary dentition, 45.6% of the students prefer to perform pulpotomy as compared with other techniques. There was no significant difference in caries removal method for permanent teeth between undergraduate year of study ($p > 0.05$), which was partial caries removal at 52.7 and 53.5%, respectively. For primary dentition, the preferred caries removal method was pulpotomy for year 4 (39.8%) and year 5 (52%) students. The popular material to restore deep caries was resin composite (42%) followed by glass ionomer cement (23.3%).

Conclusions This study showed that partial caries removal was the preferred method despite partial understanding on the identification of the clinical indicators of the technique.

Keywords
- deep caries
- complete removal caries
- partial caries removal
- dental education
- pulpotomy
- conservative dentistry

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Introduction

Dental caries is one of the most widespread noncommunicable disease. Deep caries as defined by the International Caries Detection and Assessment System can be removed through various methods.[1] These methods are complete removal and excavation technique (nonselective removal to hard dentin), partial removal and excavation (selective removal to firm, affected dentin), partial removal and excavation (selective removal to soft, infected dentin) and stepwise caries removal technique. Complete surgical excavation of carious lesion is now considered outdated and an overtreatment since this approach will lead to larger cavities, rapid progress of replacement cycle of restoration, and unnecessary loss of structural integrity of the teeth.[2] Various systematic reviews and meta-analysis supported on partial excavation of caries removal technique due to results of lower complications of pulpal integrity, such as pulpal necrosis.[3-6] Currently, the deep caries lesion with compromised pulpal integrity involves vital pulp therapy (VPT) including partial and complete pulpotomy that allows natural rejuvenation of the pulpal biological complex.[7] The success rate of VPT ranges up to 90%.[8-10] The advantages include less biological cost, faster and less technique sensitive with the utilization of biomaterials such as mineral trioxide aggregate, bioceramic, and calcium hydroxide [$Ca(OH)_2$].[11,12]

This conservative approach is part of the minimal invasive dentistry (MID) that focuses on etiology of the disease. Although the approach of MID had been introduced and advocated in the cariology and dentistry field, there are anecdotal and empirical evidences suggesting that this approach is being practiced in undergraduate clinical years as part of the compulsory training and experience. There is no available evidence regarding MID pedagogy particularly in deep caries management in Malaysian undergraduate dentistry programs. Therefore, this study aims to assess the knowledge and attitude of undergraduate dentistry students in Malaysia on the MID concept for the deep caries removal method.

Materials and Methods

Study Design

This study designated as a cross-sectional and quantitative methodology approach approved by the institutional ethical committee (Ref: USIM/JKEP/2019–53) and was conducted from August 2019 to November 2019.

Sample Size

The sample size calculation was performed by using the Raosoft Sample Size Calculator (Raosoft®, Inc., Seattle, WA, United States) (95% confidence interval). A total of 272 respondents out of 922 of 4th year and 5th year undergraduate dental students in Malaysia were selected to achieve the power calculation with an estimated dropout of 20% taken into account.

Participants

A database comprising 4th and 5th year undergraduate dental students was collected from the Malaysian Dental Council online database. Through it, a total of 303 respondents volunteered and completed the questionnaire.

Questionnaire

The questionnaire was adapted from Crespo-Gallardo et al and was a slight modification according to the needs of this study.[13] The questionnaire consists of multiple-choice questions with predefined answers offering respondents the possibility to choose several answers. It was validated through a pilot test conducted with 20 undergraduate dental students. The questionnaire was then administered and distributed as an online survey via Google Form with the corresponding link being sent via e-mail and online social platform (WhatsApp).

The questions were organized into three parts. The first part was to evaluate the demographic data of the respondents and focused on the technique and management approach used for deep caries lesion. The questions from the second part investigated the preferred treatment used for deep caries based on the perceived clinical simulation, while the third part of the questionnaire assessed the factors that affected the decision on deep caries management. The questionnaire comprised of (1) details of the respondent; (2) type of deep caries management that was learned in university; (3) management strategy for a deep lesion in a permanent and deciduous dentition with a vital, asymptomatic pulp in an adult patient; (4) factor that affects the management for deep caries lesion; and (5) preferred lining material. The details of the questionnaire are given in ►**Tables 1** to **5**. The present study focuses on deep carious lesions management and dentine excavation; endodontic procedures were not considered in the present analysis.

Statistical Analysis

The data from the Google Form were analyzed using Statistical Package for the Social Sciences (SPSS), version 21.0 software (IBM SPSS; IBM Corporation, New York, United States). Independent *t*-test was used for statistical analysis to compare between the 4th and 5th year dental students with regard to the treatment modalities based on designated clinical cases and dentin criteria upon caries removal. A *p*-value with less than 0.05 was considered as statistically significant with the sample set at 95% of confidence interval. The data was expressed in percentage unit as a result of the questionnaires.

Results

A total of 303 undergraduate dental students in Malaysia responded to the survey with the response rate of 32.8%. The other 67.2% did not respond to the questionnaires, although a second reminder was sent via e-mail and other online platform. Among the respondents, 53.1% were in 4th year of study, while 46.9% of them were in 5th year with 76.2% made

Table 1 Sociodemographic, deep caries investigations, and management based on minimally invasive technique

Variables	Percentage (%)	Frequency
Gender		
Male	23.8	72
Female	76.2	231
Years of study		
4th year	53.1	161
5th year	46.9	142
University		
Public University	81.2	246
Private University	18.8	57
Caries removal techniques learned in dental school		
Complete caries excavation	82.7	249
Partial caries removal	60.5	158
Stepwise technique	49.0	112
Atraumatic restoration technique	29.3	78
Pulpotomy	53.2	146
Hall technique	26.7	73
Nonrestorative cavity control (NRCC)	7.6	22
Have you read about the minimal invasive dentistry (MID) approach in cariology field?		
Yes	68.3	207
No	31.7	96
Routinely ask about pain history		
Yes	96.0	291
No	4.0	12
Routinely perform pulp test		
Yes	86.8	263
No	13.2	40
Pulp testing method regularly used:		
Cold testing	82.1	249
Hot testing	35.3	105
Electric pulp testing	89.8	244
Routinely take radiograph		
Yes	89.4	271
No	10.6	32
Type of radiograph taken		
Periapical	84.8	257
Bitewing	22.7	69
Criteria that will stop from further removal based on dentin hardness		
Dentin hardness has no influence on my excavation	7.9	24
When the floor is leather like	8.6	26
When the floor of cavity feels hard	59.1	179
When the floor of cavity feels hard and there is a screeching Scratch	20.8	63
When the floor of cavity is soft	3.6	11
Criteria that will stop from further removal based on color of dentin		
Color of dentin has no influence on my excavation	7.6	23
When the floor of the cavity has a dark stain	3.3	10

(*continued*)

Table 1 (*continued*)

Variables	Percentage (%)	Frequency
When the floor of the cavity has a dark stain (affected dentine)	65.3	198
When the floor of the cavity has a dark stain (infected dentine)	5.3	16
When the floor of the cavity is normal dentin color to yellowish	18.5	56
Criteria that will stop from further removal based on dentin moisture		
Moisture has no influence on my excavation	42.6	129
When the floor cavity is dry	44.2	134
When the floor cavity is little moist	10.9	33
When the floor cavity is very moist	2.3	7

Table 2 Management of deep caries lesion based on the cases analysis

	Case 1		Case 2		Case 3	
	A 36 years old, male, Malay • Complaint: Food stuck on the lower right posterior tooth associated with no pain • Pulp test: Normal response • Diagnosis: ICDAS code 5 with risk of pulp exposure		A 14 years old, Malay, boy • Complaint: Cavitated lesion on lower right posterior tooth (47) associated with no pain • Pulp test: Normal respond • Diagnosis: ICDAS code 5 with risk of pulp exposure		An 8 years old, Malay, girl • Complaint: Uncomfortable during eating on lower right posterior tooth (84) • Pulp test: Normal response • Diagnosis: ICDAS code 5 with risk of pulp exposure	
Based on the case, what would be your treatment option?	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency
Total caries removal ≥ pulp exposure ≥ pulp extirpation ≥ permanent restoration	0.9	3	3.6	11	3.6	11
Total caries removal ≥ pulp exposure ≥ pulp extirpation ≥ temporary restoration	8.5	26	4.9	15	1.6	5
Total caries removal ≥ pulp exposure ≥ direct pulp capping ≥ permanent restoration	31.6	96	25.4	77	7.5	23
Total caries removal ≥ pulp exposure≥ direct pulp capping ≥ temporary restoration	0	0	10.5	32	6.9	21
Total caries removal ≥ pulp exposure ≥ pulpotomy ≥ permanent restoration	1.6	5	5.9	18	30.6	93
Total caries removal ≥ pulp exposure ≥ pulpotomy ≥ temporary restoration	3.9	12	4.9	15	14.8	45
Stepwise excavation ≥ indirect pulp capping ≥ temporary restoration ≥ finish the caries removal a few weeks or months later	33	100	26.7	81	8.5	26
Partial caries removal ≥ indirect pulp capping ≥ permanent restoration	19.8	60	17.4	53	10.5	32

(*continued*)

Table 2 (*continued*)

	Case 1		Case 2		Case 3	
	A 36 years old, male, Malay • Complaint: Food stuck on the lower right posterior tooth associated with no pain • Pulp test: Normal response • Diagnosis: ICDAS code 5 with risk of pulp exposure		A 14 years old, Malay, boy • Complaint: Cavitated lesion on lower right posterior tooth (47) associated with no pain • Pulp test: Normal respond • Diagnosis: ICDAS code 5 with risk of pulp exposure		An 8 years old, Malay, girl • Complaint: Uncomfortable during eating on lower right posterior tooth (84) • Pulp test: Normal response • Diagnosis: ICDAS code 5 with risk of pulp exposure	
Seal with a crown using Hall technique without removing caries	0	0	0.3	1	10.8	33
Nonrestorative cavity control ≥ apply fluoride	0.3	1	0	0	0.9	3
Extraction or review with extraction if pain or infection	0	0	0	0	3.6	11
Material preferred in deep caries management	Percentage (%)			Frequency		
Amalgam	6.6			20		
Cavit	1.7			5		
Compomer	1.0			2		
Composite	41.7			127		
Glass Ionomer cement	23.3			71		
Giomer	0.4			1		
Intermediate restorative material	7.6			23		
Resin modified glass ionomer cement	4.7			14		
Zinc-oxide eugenol	13.1			40		

Abbreviation: ICDAS, International Caries Detection and Assessment System.

Table 3 Independent t-test for treatment based on clinical case. The significance level is set at $p < 0.05$

	Year 4		Year 5		*t*-test
	Mean	Standard deviation (±)	Mean	Standard deviation (±)	
Case 1	4.24	2.534	4.27	2.429	0.929
Case 2	5.12	3.170	4.81	2.975	0.376
Case 3	5.63	2.761	5.37	2.393	0.396

Table 4 Independent t-test for criteria of dentine upon caries removal

	Year 4		Year 5		*t*-test
	Mean	Standard deviation (±)	Mean	Standard deviation (±)	
Dentin hardness	2.70	0.928	2.89	0.731	0.048
Dentin color	3.34	1.134	3.52	1.023	0.138
Dentin moisture	1.78	0.772	1.67	0.712	0.186

Note: The significance level is set at $p < 0.05$.

up of females and the remaining 23.8% were male students. The respondents were from public and private universities in Malaysia with the percentage of 81.2 and 18.8%, respectively. Majority of them had learned various techniques in deep caries management, which include complete caries excavation (82.7%), partial caries removal (60.5%), and pulpotomy (53.2%).

Table 5 Factors affecting the material of choice, treatment options, and justification

Variables	Percentage (%)	Frequency
Management of deep caries lesion are affected		
Both decision	91.1	276
Self-decision	0.7	2
Supervisor decision	8.3	25
Preferred material for pulpal lining		
Biodentine (Septodont, France)	2.3	7
Calcium hydroxide $Ca(OH)_2$	61.4	186
Flowable resin composite	0.3	1
Glass ionomer cement (GIC)	26.7	81
Mineral trioxide aggregate (MTA)	5.9	18
Resin modified glass ionomer cement (RMGIC)	1.3	4
TeraCal (resin modified calcium silicate) (BISCO, United States)	0.3	1
Zinc oxide eugenol (ZnOE)	1.7	5
Preferred material for pulpotomy		
Biodentine (Septodont, France)	5.6	17
$Ca(OH)_2$	44.2	134
Ferric sulfate	30.7	93
Formocresol	5.6	17
MTA	13.5	41
ZnOE	0.3	1
Reasons for choosing particular treatment material for treatment intervention		
Ease of use, familiarity with the technique	70.6	214
Good clinical result	74.9	156
Recommended by supervisor/colleagues	61.7	147
Recommended by clinical research	44.8	98
Recommended in textbook	35.9	80
Cost-effectiveness	38.3	96
Factors that affect the treatment choice		
Patient's general health	51.5	158
Patient's age	76.0	278
Patient's oral health	71.1	217
Patient's attitude and preference	70.5	216
Type of tooth (anterior, premolar, molar)	74.6	228
Stage of root development (incomplete/complete)	76.4	234
Further restoration needs of tooth	60.9	184
Duration of the total treatment	42.5	131

The students performed the routine history taking and clinical investigations prior to the treatment by investigating the pain history (96%), performing pulp sensibility testing (86.8%) and conducting a radiographic examination (89.4%). It was found that the preferred clinical investigation for deep carious lesion was electric pulp testing (89.8%) and periapical radiographic view (84.8%). Majority of the students preferred to stop the caries removal when the procedure reached hard dentin (59%), when dark stained affected dentine (65%), and when the floor of cavities was dry (44.2%) (►**Table 1**).

Multiple case series with specific scenario and special investigations results were subsequently assessed as reflected in the ►**Table 2**. This was aimed to evaluate the student's attitude on substantial difference in between management of deep caries lesion for permanent, mixed, and primary dentition. The result indicated that more than half of the students (53%) preferred partial caries removal, while 13.6% chose to perform total caries removal as their preferred technique for permanent dentition caries removal. As for primary dentition, pulpotomy was favored (45.6%). There was no significant difference on the preferred technique for permanent dentition between 4th and 5th year students, as both chose partial caries removal with the former being 52.7% and latter 53.5% ($p < 0.929$). There was also no significant difference

in preferred caries removal method for immature permanent dentition and primary dentition between 4th and 5th year students as majority chose complete caries removal ($p < 0.376$) and pulpotomy ($p < 0.396$). Nonetheless, both groups have the same preference in partial caries removal. However, there is significant difference in practicing criteria of the caries removal based on the dentine hardness between 4th and 5th year undergraduate dental students ($p < 0.048$). In total, 41.7% of the respondents preferred resin composite as the material of choice for deep caries lesion management followed by glass ionomer cement (GIC) (23.3%) and zinc oxide eugenol (13.1%).

The factors that influenced the treatment choice for the management of deep carious lesion were also highlighted. Almost 91.1% of the respondents considered their clinical supervisor's recommendation and self-decision prior to the deep caries management operative procedure. Majority of them preferred to incorporate setting $Ca(OH)_2$ as a lining material (61.4%) and in pulpotomy cases (44.2%). The reasons for choosing the type of material were due to the simplicity of use (70.6%), good clinical result (74.9%), and recommended by supervisor and/or colleagues (61.7%). Several factors affected the choices of treatment option for the respondents, among them are the patient's age (76.0%), patient's oral health (71.1%), patient's attitude and preference (70.5%), type of the tooth (anterior, premolar, or molar) (74.6%), and the stage of root development (76.4%).

Discussion

This cross-sectional study marks the first study on the knowledge and practice of the deep caries management conducted by 4th and 5th undergraduate dental students throughout Malaysia. Female personnel (76.2%) and undergraduate dental students from seven major public universities in Malaysia (81.2%) that offered undergraduate courses on dentistry were the majority participants in this study. Despite the fact that the respondents were only 32.8% from the total available potential participants, this still represented more than a third of the total 4th and 5th year undergraduate dental students in Malaysia. The Malaysian undergraduate dental students were familiar with an extensive range of basic caries investigation and caries removal techniques including dental pain history, pulp sensibility testing and radiographic investigation with complete, partial, and stepwise caries removal approaches. In this study, we observed that 68.3% which represented 207 individuals from the overall participants were aware of the MID approach. This showed that there is a paradigm shift in undergraduate dental curriculum and pedagogy toward overall caries management based on MID. The clinical staging of the caries is paramount in determining the overall prognosis, potential treatment plan with suitable preventative measures in managing deep carious lesion. The distinct visibility of the dentine, as well as the soft and leathery on gentle probing, is an indication of the extensive caries classification with active surface lesions.[10] Nevertheless, in our study, we found that undergraduates had mixed opinions and responses on the necessities to stop caries removal such as dentine color, consistency, and moisture with majority of them choosing to remove hard (59.1%), dark stained (65.3%), and dry (44.1%) dentine that indicated a complete caries removal approach which was not consistent and contradicted the MID principles.

A series of clinical cases with specific clinical scenario complemented with special investigations and diagnoses were given to investigate the attitude of the participants toward deep caries management practice. In permanent dentition, a third (33%) of the respondents chose complete caries removal technique with 52.8% selected stepwise excavation technique and partial caries removal. The approach of the practicing dentists in deep caries management of the permanent teeth is in conflict and showed vast variations in clinical techniques in different parts of the world. A survey to Australian and Finland practicing dentists showed that the majority of the respondents adopted MID approach in which they selected selective and stepwise caries removal with 85 and 64% in deep caries management, respectively.[14,15] However, another cohort of dentists in Saudi Arabia and Spain showed the tendency to choose complete caries removal on asymptomatic and symptomatic deep carious lesion with 82.5 and 80%, respectively.[13,16] In mixed and deciduous dentition cases, 31.3 and 38.1% opted for complete caries removal in an asymptomatic and healthy pulp, respectively. There was a small cumulative data which analyzed the knowledge and attitude of practicing dentists on the management of deep carious lesion on primary dentition. A nationwide survey conducted by Koopaeei et al showed that the 68% of the general dentists and 47% of the endodontists tend to practice complete caries removal as compared with pediatrics dentists who were more likely to opt for selective caries removal.[17] Another survey by Muller-Bolla et al showed the same trend in which majority of the dentists (68%) chose complete caries removal in a single visit.[18] Amalgam is still the preferred choice for deep caries restorative materials for a small number of respondents (6.6%) even though the collaborative focus on utilizing resin composite in MID era.[19] A consistency in knowledge and preference was detected for case series analysis of deep caries management between 4th and 5th year dental students (►**Table 3**). However, there was a significance tendency ($p < 0.05$) of complete caries removal in 4th year as compared with 5th year undergraduate dental students in the dentine hardness perspective as the indicator for deep carious lesion. A clinical experience in the context of advancing years of study influenced the decision and competency for the partial caries removal technique. In this study, there is a need for an instant response on educating future dentists in shifting the attitude toward selective caries removal in the domain of deep caries management.

A clear majority of 91.1% respondents decided that both factors of supervisors and self-decision are needed to achieve a clinical agreement on management for deep caries lesion that in turn reflected a dependency on the clinical faculty members. One of the paramount concepts in MID is to maintain pulp vitality in an already inflamed pulp-dentine complex. The main aim of pulp capping is to protect the pulp tissue complex from potential irritation particularly bacteria in nature.[20]

About 88.1% of the respondents selected $Ca(OH)_2$ and GIC as the preferred materials used in pulpal lining that are in line with the recommendation and results showed from other studies.[21-23] Pulpotomy is a routinely performed clinical procedure with high clinical success to eliminate bacteria followed by the placement of a suitable material or medicament within the pulp chamber complex to maintain vitality of primary teeth until exfoliation to prevent the need of pulpectomy.[24] Approximately two-third of the respondents (74.9%) selected $Ca(OH)_2$ and ferric sulfate as the material of choice that is parallel with the current literature advocating material selection for pulpotomy. An emerging popularity of MTA as the superior material of choice is reflected in this study as well with 13.5% respondents choosing it. However, the number is lesser due to the probability of high material cost and potential risks of tooth discoloration.[25-27] Nevertheless, 5.6% of the respondents still chose formocresol as the material of choice despite its known issue for toxicity.[28] More than two-third of the respondents gave the reason to their preferred material due to relatively ease of clinical usage with good clinical results that depicted the clinical techniques and the evidence-based outcome of this material that is well described in the undergraduate curriculum policy and content. A comprehensive list of the factors that affects the treatment choice chosen and description by the respondents is also included in this study as well. The patient's age, overall oral health, attitude, and preference toward the treatment proposed, type, and location of the tooth and stage of root development were the most patient-related factors taken into account for treatment of choice.

The major limitation in this study is that the total participants merely consist of only one third of 4th and 5th year undergraduate dental students in Malaysia. More recruitment of participants from nation-wide dental schools will promise a true reflection of knowledge, attitude, and practice of deep caries management for this study.

Conclusions

The partial caries removal technique in deep caries management is well adopted and implemented in undergraduate curriculum design and content based in this nation-wide survey on undergraduate students in Malaysia. However, there is a partial understanding on the practice of this approach reflected by the survey in the case discussion analysis. Maximum efforts should be made to translate the growing evidence of partial, conservative caries removal into the curriculum syllabus in managing deep carious lesion. There is an urgent need to enhance the MID pedagogy regarding preclinical and clinical education training on the partial caries removal method in undergraduate dental curriculum in Malaysia.

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Conflict of Interest

None declared.

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