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## Approaches of General and Specialist Dentists to Deep Caries Management: A Cross-Sectional Study from Turkey

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### Cover Page Footnote

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**ORIGINAL ARTICLE**

**Approaches of General and Specialist Dentists to Deep Caries Management: A Cross-Sectional Study from Turkey**

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**ABSTRACT**

**Objective:** To determine the differences in treatment strategies and material preferences for deep dentine carious lesions (DDCLs) management among general and specialist dentists. **Methods:** Dentists working in universities, oral and dental health centers, or private practice were administered a 14-item web-based questionnaire regarding demographic and occupational characteristics, approaches to DDCLs, pulp capping methods, and preferences for restorative materials. The data were examined using descriptive statistical analysis and Pearson's chi-square tests. **Results:** The study enrolled 298 general and 265 specialist dentists among whom 67.1% were female and 73.3% were aged 25 to 35 years. Total excavation and permanent restoration of DDCLs were the commonly preferred treatments (67.0%), although the pediatric dentists tended toward selective caries removal in these lesions. Mineral trioxide aggregate was used more regularly by the pediatric dentists and endodontists. The pediatric dentists exhibited statistically significantly lower preference for canal treatment than general dentists and endodontists as treatment option for mature teeth with DDCLs ( $p < 0.05$ ). **Conclusion:** Conservative treatment approaches and material preferences of specialists and general dentists in DDCLs are generally different. The age of dentists, the time since their graduation, place of work and the number of patients they have seen daily may affect the approaches and preferences.

**Key words:** caries excavation, deep dentine caries lesion, general dentist, specialist dentist, treatment approach

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**INTRODUCTION**

Dental caries is a chronic, dietary, progressive, and polymicrobial disease that results in the dissolution and destruction of calcified hard tissues of the primary and permanent dentition.<sup>1</sup> It is not an infectious disease that can only be treated by removing a particular type of bacteria. It can be behaviorally managed by controlling causal factors such as the supply of fermentable carbohydrates, the presence and maturation of bacterial dental biofilms.<sup>1</sup> According to a 2015 Global Burden of Disease study, untreated permanent tooth decay affects 2.5 billion people worldwide, and untreated primary teeth caries affects 573 million children.<sup>2</sup> Although the prevalence of caries is decreasing in high-income countries, it continues to be a major global public health problem.<sup>2</sup> It can progress when left untreated, causing severe consequences for oral and general health as well as increased treatment costs.<sup>2,3</sup>

The traditional protocol for caries treatment involves the removal of all carious tissues, but more conservative approaches have been proposed in recent years.<sup>4</sup> Recommendations in this regard were presented at the International Caries Consensus Collaboration meeting, organized in Belgium, in February 2015.<sup>1</sup> The expert consensus advises arresting or controlling existing lesions through minimal invasive restorative treatment and priority is maintaining pulp health and remineralizing hard tissue. There are two recommended techniques for this purpose. The first is selective caries removal, which is applied by permanently restoring the soft caries remaining on the pulpal wall. This technique is recommended for deep dentine carious lesions (DDCLs) in the primary or permanent dentition. The second is stepwise excavation, in which the soft caries remaining on the pulpal wall is eliminated after

two to 24 months and then permanently restored. This approach applies to DDCLs in the permanent dentition.<sup>1</sup> In both techniques, an essential requirement is to maintain the vitality of the pulp. The purpose of vital pulp treatments (direct pulp capping [DPC] and partial pulpotomy) are to prevent the progression of inflammation towards pulp necrosis, to eliminate the need for Root Canal Treatment (RCT) and to maintain pulp viability.<sup>5</sup> It has been reported that the 5-year success rates of vital pulp treatments are comparable to conventional pulpectomy and RCT.<sup>6</sup>

Complete caries removal to sound dental tissue has been considered the gold standard treatment for decayed teeth for many years. However, with the advances in understanding etiopathogenesis and advances in adhesive materials, minimal invasive approaches have begun to be preferred.<sup>7</sup> It is known that there is inconsistency in the management of carious lesions in clinical practice.<sup>7</sup> Various studies have investigated the conservative approaches adopted by general dentists (GDs) in treating DDCLs, but researches that compare the attitudes and behaviors of general and specialist dentists in addressing the condition is limited.<sup>3, 8</sup> One such study was carried out at Michigan University to compare the diagnostic approaches and treatment preferences of GDs and specialist dentists (endodontists [EDs] and pediatric dentists [PDs]) as regards DDCLs. The majority of the participants favored complete carious tissue removal, but the PDs adopted a more conservative approach to intervention.<sup>3</sup>

To the best of our knowledge, no study has compared the DDCL-related treatment and restorative material preferences of general and specialist dentists in Turkey. Accordingly, this study was conducted to determine the differences between dentists' strategies and material preferences for DDCL management according to the employed professional institution, professional experience period, and specialty in the chosen context. The null hypothesis adopted in this work holds that no difference exists between these practitioners with respect to preferences for DDCLs intervention.

## METHODS

This cross-sectional study was conducted from October to December 2019 using a web-based survey. The research protocol was approved by the Ethics Committee of Mersin University in Turkey and was conducted in accordance with the most recent guidelines of the Declaration of Helsinki. The study was conducted following STROBE guidelines.<sup>9</sup> The sample size was calculated based on the total target population for GDs and specialist dentists (openepi.com/SampleSize). The total number of dentists in Turkey (n = 32.859, according to the data of the Ministry of Health of Turkey) and a precision level of

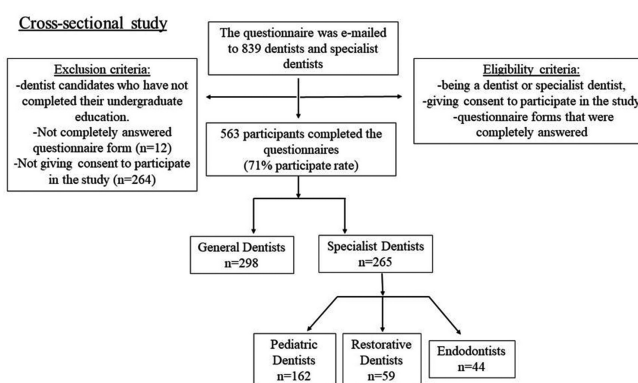


Figure 1. Flow chart for sample selection process

± 5% for the 95% confidence interval (CI) were used to calculate the number of dentists to be included. A non-response rate of 20% was added for a final sample size estimated at n = 380 dentists. According to the data of the Ministry of Health of Turkey for 2020, 22.8% of dentists are specialists. Based on this data, it was calculated that 86 specialist dentists and 294 GDs should be included in the study.

## Questionnaire

An electronic questionnaire (GoogleForms©) was developed specifically for this study. And the questions used in the present work were modified from previous questionnaires validated by Kakudate et al.<sup>10</sup>, Crespo-Gallardo et al.<sup>4</sup>, and Chisini et al.<sup>11</sup> (Table 1). A pilot-testing on 20 dentists was conducted and subject to minor adjustments on the questionnaire. The sampling method for the web-based questionnaire was the closed population list of probability sampling category.<sup>12</sup> The internet link of questionnaire was sent to general and specialist dentists (Restorative Dentists [RDs], EDs, PDs) working in public and private dental health institutions in Turkey via email and social media (WhatsApp©). All invitations were sent to dental professionals from an email list of the Turkish Dental Association. Eligibility criteria were as follows: being a dentist or specialist dentist, giving consent to participate in the study and questionnaire forms that were completely answered. Exclusion criteria consisted of dentist candidates who have not completed their undergraduate education (shown in Figure 1). A reminder message was sent two weeks later to increase the participant ratio and minimize the risk of bias.

The questionnaire in the current research contained a section that explains the aim of the study. The initial part consisted of 12 questions intended to elicit information on demographic/ occupational characteristics of participants and preferences for restorative materials and approaches to DDCLs treatment (the selective or complete removal of caries and pulp capping methods). Second part of the questionnaire included two questions involved clinical case scenarios with periapical radiographs. The institutions where the participants

Table 1. Questionnaire Regarding Attitudes, Behaviors and Treatment Preferences of Dentists Regarding Deep Dentin Carious Lesions

1. In which age range are you?	<input type="checkbox"/> 25-35	<input type="checkbox"/> 36-45	<input type="checkbox"/> ≥46
2. What is your gender?	<input type="checkbox"/> Female	<input type="checkbox"/> Male	
3. What is your employed professional institution?	<input type="checkbox"/> University	<input type="checkbox"/> Oral-dental health center (ODHC)	<input type="checkbox"/> Private clinic
4. How long has it been since graduation?	<input type="checkbox"/> ≤10	<input type="checkbox"/> >10	
5. What is your specialty	<input type="checkbox"/> General dentistry	<input type="checkbox"/> Pediatric dentistry	<input type="checkbox"/> Restorative dentistry
6. How many patients do you treat per day?	<input type="checkbox"/> <5	<input type="checkbox"/> 5-10	<input type="checkbox"/> >10
7. What is your preferred pulp capping material for deep dentin carious lesions?	<input type="checkbox"/> Calcium Hydroxide (Dycal)	<input type="checkbox"/> Resin-modified calcium silicate filled liner (Theracal)	<input type="checkbox"/> Biodentine
8. What is your preferred restorative material order for the treatment of deep dentin carious lesions without pulp perforation?	<input type="checkbox"/> Pulp capping material + Adhesive system + Composite resin	<input type="checkbox"/> Pulp capping material + Glass ionomer cement + Adhesive system + Composite resin	<input type="checkbox"/> Calcium enriched cement (CEM)
9. What is your treatment approach to a tooth with deep dentin carious lesion?	<input type="checkbox"/> Glass ionomer cement + Adhesive system + Composite resin	<input type="checkbox"/> Adhesive system + Composite resin	
10. What is the most effective option for deciding on adequate removal of caries near the pulp?	<input type="checkbox"/> Pulp capping material + Zinc oxide eugenol cement+ Amalgam	<input type="checkbox"/> I remove the caries completely and seal the cavity with a temporary filling.	
11. Which of the caries removal methods do you use in deep dentin carious lesions?	<input type="checkbox"/> I remove the caries completely and seal the cavity with a permanent restoration.	<input type="checkbox"/> To avoid any damage to the pulp, I partially remove the caries and seal the cavity with a temporary restoration.	
12. What is your approach to leave carious tooth tissue under the restoration?	<input type="checkbox"/> To avoid any pulp damage, I partially remove the caries and seal the cavity with a permanent restoration.	<input type="checkbox"/> Checking the hardness of the remaining dentin with the excavator	
13. In the anamnesis of a twenty-year-old patient with an occlusal deep dentin caries in the permanent lower right first molar tooth, it was observed that there were no complaints of pain that increased with heat or spontaneously, and there was no percussion pain in the intraoral examination. In the periapical radiograph of the patient, it was determined that the caries was very close to the pulp and there was no pathological condition in the periapical or furcation area. What would your treatment approach be in this patient?	<input type="checkbox"/> Removing until there is no discolored dentin in the cavity	<input type="checkbox"/> Removing the caries until a shiny surface is obtained on the dentin	
14. In the anamnesis of an eight (8) year old patient with occlusal deep dentin caries in the permanent lower right first molar tooth, it was observed that there were no complaints of pain that increased with heat or spontaneously, and there was no percussion pain in the intraoral examination. It was determined that there was no pathological condition, but the root development of the tooth was incomplete. What would your treatment approach be in this patient?	<input type="checkbox"/> Caries staining solutions using additional caries diagnostic methods such as laser fluorescence	<input type="checkbox"/> Traditional caries removal methods (excavators, diamond and steel metal burs)	
	<input type="checkbox"/> Alternative caries removal methods (chemomechanical methods, air-abrasion, air-polishing, laser etc.)	<input type="checkbox"/> Cariogenic micro-organisms need to be completely removed, caries may otherwise progress.	
	<input type="checkbox"/> A certain amount of cariogenic microorganism can be left because intact restorations can clog caries and thus caries progression can be stopped.	<input type="checkbox"/> Caries must be completely removed because residual caries poses a risk to pulp vitality.	
	<input type="checkbox"/> To avoid pulp exposure, caries near the pulp should be left.		
	<input type="checkbox"/> Indirect capping by removing only light-colored soft caries and leaving dark-colored hard caries		
	<input type="checkbox"/> Cleaning entire caries until there is no discolored dentin left, and if there is a perforation of less than 0.5 mm in the pulp performing direct capping		
	<input type="checkbox"/> Root canal treatment		
	<input type="checkbox"/> Indirect capping by removing only light-colored soft caries and leaving dark-colored hard caries		
	<input type="checkbox"/> Cleaning entire caries until there is no discolored dentin left, and if there is a perforation of less than 0.5 mm in the pulp performing direct capping		
	<input type="checkbox"/> Apexification therapy		



**Figure 2.** Periapical radiograph image of clinical case scenario-1



**Figure 3.** Periapical radiograph image of clinical case scenario-2

were working were classified as universities, private clinics (PC), and oral–dental health centers (ODHC). Time since graduation was classified into “up to 10 years” or “more than 10 years.”

#### **Clinical case scenarios**

What would be your approach to addressing the conditions of the patients in the following scenarios?

Case 1. Spontaneous pain was not observed in the right permanent mandibular first molar in the anamnesis of a 20-year-old patient with occlusal DDCL and cold sensitivity. However, percussion pain was not observed in the clinical examination. Periapical radiography revealed complete root development and profound caries very close to the pulp. However, no pathological condition in the periapical or furcation area was detected (shown in Figure 2).

Case 2. Spontaneous pain was not observed in the left permanent mandibular first molar in the anamnesis of an eight-year-old patient with occlusal DDCL

and cold sensitivity. However, percussion pain was not observed in the clinical examination. Periapical radiography revealed profound caries very close to the pulp, although no pathological condition was detected in the periapical or furcation area. However, the root development of the tooth was incomplete (shown in Figure 3).

#### **Statistical analysis**

Statistical analysis was performed using the statistical package SPSS software (Version 25.0, SPSS Inc., Chicago, IL, USA). The categorical variables between the groups were analyzed by using the Chi-square test. Statistical significance was set at  $p < 0.05$ .

## **RESULTS**

#### **Demographic/ occupational characteristics of participants**

The questionnaire was e-mailed to 839 participants, general dentists (574 GDs) and specialist dentists (162 PDs, 59 RDs, and 44 EDs) among whom 563 completed the questionnaires (71% participation rate). Females constituted 67.1% of the sample. Most of the participants were aged 25 to 35 years old (73.3%). The proportions of participants working in universities, ODHC, and PC were 34.3%, 33.8%, and 31.8%, respectively. Of the sample, the GDs constituted 52.9%, and the dentists who graduated less than 10 years ago accounted for 68.3% (Table 2).

#### **Restorative material preferences of participants for the treatment of DDCLs**

Pulp capping material (PCM) considered being the most effective in the treatment of DDCLs was mineral trioxide aggregate (MTA) (52.6%), but the most used PCM was Dycal (59.1%). In terms of treatment approach, most of the participants (67.0%) reported that they would remove all infected and affected tissues and close cavities through permanent restoration. The most preferred application order of materials among the dentists was PCM + Glass Ionomer Cement (GIC) + Adhesive System (AS) + Composite Resin (CR) (47.6%) (Table 2).

#### **Impact of the employed professional institution, experience and specialty on DDCL treatment procedures**

Table 3 shows statistically significant differences among the responses of the participants employed in different institutions ( $p < 0.05$ ). In the first clinical scenario, it could be seen that the participants working at the university preferred indirect pulp capping (IPC) more as a treatment approach than the others (ODHC and PC), while they preferred RCT at a lower rate. In the second clinical case with an open apex, it was observed that dentists working in ODHC preferred apexification treatment at a higher rate.

**Table 2.** Demographic characteristics of participants and question items for DDCLs management (N=563)

		n	%
Age	25-35	412	73.3
	36-45	117	20.9
	≥46	34	5.9
Gender	Female	376	67.1
	Male	187	32.9
Professional institution	University	194	34.3
	ODHC	190	33.8
	PC	179	31.8
Time since graduation	≤10 years	384	68.3
	>10 years	179	31.7
Dentist/specialist	GDs	298	52.9
	PDs	162	28.8
	RDs	59	10.5
	EDs	44	7.8
Number of patients seen per day	<5	66	11.5
	5-10	226	40.1
	>10	271	48.4
Considering the current clinical conditions, the most used PCM	Dycal	331	59.1
	TheraCal	125	22.1
	MTA	91	16.1
	BD&CEM	16	2.7
PCM considered to be the most successful	Dycal	130	23.1
	TheraCal	70	12.3
	MTA	295	52.6
	BD&CEM	68	12.0
Preferring restorative material order for the treatment of DDCLs without pulp perforation	PCM + AS + CR	98	17.4
	PCM + GIC + AS + CR	267	47.6
	GIC + AS + CR	85	15.0
	AS + CR	32	5.7
	PCM + ZnOE + Amalgam	81	14.3
What is your treatment approach to a tooth with DDCLs?	TE + TR	59	10.5
	TE + PR	377	67.0
	SCR + TR	59	10.5
The most effective situation in deciding that caries close to the pulp removed sufficiently	SCR + PR	68	11.9
	Check with excavator	402	71.5
	Color&Dentine consistency	138	24.6
Preferring alternative caries removal methods	Guided by caries indicator dye or LF	23	3.9
	Yes	34	5.9
Approaching to leave carious tooth tissue under the restoration	No	529	94.1
	Cariogenic micro-organisms need to be completely removed.	287	51.1
Monitoring current approaches in dentistry	A certain amount of cariogenic micro-organisms can be left behind	276	48.9
	Through academic publications and books	253	45.0
	Through scientific congresses and seminars	219	38.9
Case 1	Not monitored	91	16.1
	IPC	357	63.6
	DPC	182	32.3
Case 2	RCT	24	4.1
	IPC	409	73.0
	DPC	129	22.7
	Apexification	25	4.3

ODHC: Oral and Dental Health Center, PC: Private Clinic, GDs: General Dentists, PDs: Pediatric Dentists, RDs: Restorative Dentists, EDs: Endodontists, PCM: Pulp Capping Material, DDCLs: Deep Dentine Caries Lesions, MTA: Mineral Trioxide Aggregate, AS: Adhesive System, BD&CEM: Biodentine and Calcium Enriched Mixture, CR: Composite Resin, GIC: Glass Ionomer Cement, ZnOE: Zinc Oxide Eugenol, TE: Total Excavation, SCR: Selective Caries Removal, TR: Temporary Restoration, PR: Permanent Restoration, LF: Laser Fluorescence, IPC: Indirect Pulp Capping, DPC: Direct Pulp Capping, RCT: Root Canal Treatment

**Table 3.** Association between dentists' professional institution and DDCL treatment procedures

		University n(%)	ODHC n(%)	PC n(%)	p-value
The most used PCM	Dycal	105 <sup>a</sup> (55.0)	150 <sup>b</sup> (79.4)	72 <sup>c</sup> (40.9)	<b>&lt;0.01</b>
	Theracal	41 <sup>a</sup> (21.5)	24 <sup>b</sup> (12.2)	60 <sup>c</sup> (34.1)	
	MTA	46 <sup>a</sup> (22.0)	13 <sup>b</sup> (6.3)	37 <sup>a</sup> (20.5)	
	BD&CEM	3 <sup>a</sup> (1.6)	4 <sup>a</sup> (2.1)	8 <sup>a</sup> (4.5)	
PCM considered to be the most successful	Dycal	17 <sup>a</sup> (8.3)	85 <sup>b</sup> (44.7)	29 <sup>a</sup> (16)	<b>&lt;0.01</b>
	Theracal	19 <sup>a</sup> (9.4)	21 <sup>a</sup> (10.6)	31 <sup>a</sup> (17.1)	
	MTA	121 <sup>a</sup> (62.5)	75 <sup>b</sup> (39.4)	98 <sup>a</sup> (56.0)	
	BD&CEM	38 <sup>a</sup> (19.8)	10 <sup>b</sup> (5.3)	19 <sup>a,b</sup> (10.9)	
The most preferred application order of restorative materials	PCM + AS + CR	28 <sup>a</sup> (14.2)	24 <sup>a</sup> (12.2)	46 <sup>b</sup> (25.4)	<b>&lt;0.01</b>
	PCM GIC + AS + CR	99 <sup>a</sup> (51.6)	74 <sup>b</sup> (38.3)	95 <sup>a</sup> (53.1)	
	GIC + AS + CR	44 <sup>a</sup> (22.6)	20 <sup>b</sup> (10.6)	21 <sup>b</sup> (11.9)	
	AS + CR	16 <sup>a</sup> (8.4)	6 <sup>a</sup> (3.2)	10 <sup>a</sup> (5.6)	
	PCM + ZnOE + Amalgam	6 <sup>a</sup> (3.2)	67 <sup>b</sup> (35.6)	7 <sup>a</sup> (4.0)	
The treatment approach	TE + TR	16 <sup>a</sup> (8.3)	20 <sup>a</sup> (10.6)	22 <sup>a</sup> (12.4)	<b>&lt;0.01</b>
	TE + PR	115 <sup>a</sup> (58.9)	135 <sup>b</sup> (70.7)	129 <sup>b</sup> (71.8)	
	SCR + TR	28 <sup>a</sup> (14.6)	13 <sup>b</sup> (6.9)	18 <sup>a,b</sup> (10.2)	
	SCR + PR	35 <sup>a</sup> (18.2)	22 <sup>a,b</sup> (11.7)	10 <sup>b</sup> (5.6)	
	Check with excavator	139 <sup>a</sup> (72.4)	132 <sup>a</sup> (69.8)	128 <sup>a</sup> (71.6)	
The most effective situation in deciding that caries close to the pulp removed sufficiently	Color & Dentine consistency	39 <sup>a</sup> (20.3)	57 <sup>a</sup> (29.1)	46 <sup>a</sup> (25.0)	<b>&lt;0.01</b>
	Guided by caries indicator dye or LF	14 <sup>a</sup> (7.3)	2 <sup>b</sup> (1.1)	6 <sup>a,b</sup> (3.4)	
Case 1	IPC	143 <sup>a</sup> (73.4)	113 <sup>b</sup> (58.7)	104 <sup>b</sup> (58.2)	<b>0.01</b>
	DPC	50 <sup>a</sup> (26)	66 <sup>a</sup> (34.9)	64 <sup>a</sup> (36.2)	
	RCT	1 <sup>a</sup> (0.5)	12 <sup>b</sup> (6.3)	10 <sup>b</sup> (5.6)	
Case 2	IPC	155 <sup>a</sup> (79.7)	132 <sup>a</sup> (69.1)	125 <sup>a</sup> (69.3)	<b>&lt;0.01</b>
	DPC	36 <sup>a</sup> (18.8)	46 <sup>a</sup> (24.5)	45 <sup>a</sup> (25.6)	
	Apexification	3 <sup>a</sup> (1.6)	12 <sup>b</sup> (6.4)	9 <sup>a,b</sup> (5.1)	

ODHC: Oral and Dental Health Center, PC: Private Clinic, PCM: Pulp Capping Material, DDCLs: Deep Dentine Caries Lesions, MTA: Mineral Trioxide Aggregate, AS: Adhesive System, BD&CEM: Biodentine and Calcium Enriched Mixture, CR: Composite Resin, GIC: Glass Ionomer Cement, ZnOE: Zinc Oxide Eugenol, TE: Total Excavation, SCR: Selective Caries Removal, TR: Temporary Restoration, PR: Permanent Restoration, LF: Laser Fluorescence, IPC: Indirect Pulp Capping, DPC: Direct Pulp Capping, RCT: Root Canal Treatment  
p values are based on the Pearson Chi-Square test and p<0.05 is significant. Different lowercase letters (a, b) represent the statistical difference between the groups on the same line.

Additionally, relationship between the professional experience period of dentists and their preferences for treatment for DDCLs is shown in Table 4. MTA was described as the most successful PCM by the group who graduated less than 10 years ago, however statistically significantly more used by the group who graduated more than 10 years ago (p=0.02). Dycal was nonetheless the most frequently used material by both groups. For the first clinical case scenario, participants who graduated less than 10 years ago preferred IPC at a significantly higher rate (66.7%)

and RCT at a significantly lower rate (2.6%) than the participants graduated more than 10 years ago. For the second clinical scenario, treatment preferences among participants with different experience were the same (p>0.05) (Table 4).

Table 5 shows that there is a statistically significant difference between the approaches of general dentists/ specialist dentists and general dentists/ subgroups of specialist dentists to DDCLs (p<0.05).



**Table 4.** The relation between dentists' time since graduation dates and procedures for the treatment of DDCLs

Graduation time		≤10 n (%)	>10 n (%)	p-value
The most used PCM	Dycal	229 <sup>a</sup> (60.3)	101 <sup>a</sup> (56.2)	<b>0.02</b>
	Theracal	93 <sup>a</sup> (24.2)	33 <sup>a</sup> (18)	
	MTA	54 <sup>a</sup> (13.7)	38 <sup>b</sup> (21.3)	
	BD&CEM	7 <sup>a</sup> (1.8)	8 <sup>a</sup> (4.5)	
PCM considered to be the most successful	Dycal	60 <sup>a</sup> (15.8)	67 <sup>b</sup> (37.9)	<b>&lt;0.01</b>
	Theracal	49 <sup>a</sup> (12.6)	22 <sup>a</sup> (11.9)	
	MTA	224 <sup>a</sup> (58.4)	75 <sup>b</sup> (40.7)	
	BD&CEM	50 <sup>a</sup> (13.2)	17 <sup>a</sup> (9.6)	
The most preferred application order of restorative materials	PCM + AS + CR	60 <sup>a</sup> (15.8)	36 <sup>a</sup> (20.2)	<b>&lt;0.01</b>
	PCM + GIC + AS + CR	199 <sup>a</sup> (52.5)	66 <sup>b</sup> (37.1)	
	GIC + AS + CR	63 <sup>a</sup> (16.1)	25 <sup>a</sup> (12.9)	
	AS + CR	20 <sup>a</sup> (5.3)	14 <sup>a</sup> (6.7)	
	PCM + ZnOE + Amalgam	39 <sup>a</sup> (10.3)	41 <sup>b</sup> (23.0)	
	TE + TR	33 <sup>a</sup> (8.7)	26 <sup>b</sup> (14.6)	
The treatment approach	TE + PR	253 <sup>a</sup> (66.4)	125 <sup>a</sup> (68)	<b>0.02</b>
	SCR + TR	40 <sup>a</sup> (10.5)	19 <sup>a</sup> (10.7)	
	SCR + PR	55 <sup>a</sup> (14.4)	12 <sup>b</sup> (6.7)	
	Check with excavator	275 <sup>a</sup> (72.0)	124 <sup>a</sup> (70.1)	
The most effective situation in deciding that caries close to the pulp removed sufficiently	Color&Dentine consistency	94 <sup>a</sup> (24.6)	44 <sup>a</sup> (24.9)	0.63
	Guided by caries indicator dye or LF	13 <sup>a</sup> (3.4)	9 <sup>a</sup> (5.1)	
	IPC	258 <sup>a</sup> (66.7)	102 <sup>b</sup> (57.3)	
<b>Case 1</b>	DPC	117 <sup>a</sup> (30.7)	63 <sup>a</sup> (35.4)	<b>0.01</b>
	RCT	10 <sup>a</sup> (2.6)	13 <sup>b</sup> (7.3)	
	IPC	284 <sup>a</sup> (74.7)	124 <sup>a</sup> (68.9)	
<b>Case 2</b>	DPC	79 <sup>a</sup> (20.8)	49 <sup>a</sup> (27.1)	0.25
	Apexification	18 <sup>a</sup> (4.5)	9 <sup>a</sup> (4.0)	

PCM: Pulp Capping Material, DDCLs: Deep Dentine Caries Lesions, MTA: Mineral Trioxide Aggregate, AS: Adhesive System, BD&CEM: Biodentine and Calcium Enriched Mixture, CR: Composite Resin, GIC: Glass Ionomer Cement, ZnOE: Zinc Oxide Eugenol, TE: Total Excavation, SCR: Selective Caries Removal, TR: Temporary Restoration, PR: Permanent Restoration, LF: Laser Fluorescence, IPC: Indirect Pulp Capping, DPC: Direct Pulp Capping, RCT: Root Canal Treatment

p values are based on the Pearson Chi-Square test and p<0.05 is significant. The different lowercase letters (a, b) represent the statistical difference between the groups on the same line.

## DISCUSSION

The treatment of DDCLs is an important part of dentists' routine clinical activities. Matters of concern, however, are the variety in approaches adopted by dentists and the diagnostic criteria and therapeutic protocols implemented in treatment.<sup>4, 13</sup> The purpose of the present study was to investigate the clinical decision-making evaluation criteria, treatment strategies, and material preferences in DDCL management among GDs and specialists. The present study showed that specialist dentists have more conservative decisions in DDCLs. According to the specialization, there was a

difference in restorative caries management related to clinical cases with DDCLs. This result indicates that there is a lack of standardization among physicians in the treatment of deep carious lesions.

The use of questionnaires to evaluate dentists' attitudes, decision-making strategies, and knowledge is a valid research method.<sup>3</sup> To enhance the validity of this study and limit bias, the questionnaire was first examined for objectivity, reliability, and validity. Previous investigations into dentists' approaches to vital pulp

**Table 5.** The relation between dentists' specialties and treatment procedures for DDCLs

		<b>GDs</b> <b>n (%)</b>	<b>Specialist</b> <b>n (%)</b>	<b>PDs</b> <b>n (%)</b>	<b>RDs</b> <b>n (%)</b>	<b>EDs</b> <b>n (%)</b>	<b>p-value</b>
The most used PCM	Dycal	202 <sup>a</sup> (68)	129 (49.0)	75 <sup>b,c</sup> (46.9)	38 <sup>a,c</sup> (64.4)	16 <sup>b</sup> (36.4)	<b>&lt;0.001*</b>
	Theracal	66 <sup>a</sup> (22.2)	58 (22.1)	34 <sup>a</sup> (19.4)	15 <sup>a</sup> (25.4)	12 <sup>a</sup> (27.3)	
	MTA	22 <sup>a</sup> (7.4)	68 (25.9)	46 <sup>b</sup> (28.8)	6 <sup>a</sup> (10.2)	16 <sup>b</sup> (36.4)	
	BD&CEM	7 <sup>a</sup> (2.4)	8 (3.0)	8 <sup>a</sup> (5.0)	0 <sup>a</sup> (0.0)	0 <sup>a</sup> (0.0)	
PCM considered to be the most successful	Dycal	109 <sup>a</sup> (36.9)	20(7.6)	7 <sup>b</sup> (4.3)	9 <sup>c</sup> (15.3)	4 <sup>b,c</sup> (9.1)	<b>&lt;0.001*</b>
	Theracal	49 <sup>a</sup> (16.6)	20(7.6)	5 <sup>b</sup> (3.1)	8 <sup>a</sup> (13.6)	7 <sup>a</sup> (15.9)	
	MTA	117 <sup>a</sup> (39.7)	177(67.0)	119 <sup>b</sup> (72)	36 <sup>b</sup> (59.3)	26 <sup>a,b</sup> (59.1)	
The most preferred application order of restorative materials	Biodentin&CEM	20 <sup>a</sup> (6.8)	47(17.8)	33 <sup>b</sup> (20.5)	7 <sup>a,b</sup> (11.9)	7 <sup>a,b</sup> (15.9)	<b>&lt;0.001*</b>
	PCM + AS + CR	63 <sup>a</sup> (21.3)	34 (12.9)	14 <sup>b</sup> (8.6)	11 <sup>a,b</sup> (19.3)	9 <sup>a,b</sup> (20.5)	
	PCM + GIC + AS + CR	128 <sup>a</sup> (43.2)	138 (52.5)	96 <sup>b</sup> (59.3)	20 <sup>a</sup> (35.1)	24 <sup>a,b</sup> (50.0)	
	GIC + AS + CR	25 <sup>a</sup> (8.4)	59 (22.4)	41 <sup>b</sup> (25.3)	13 <sup>b</sup> (22.8)	5 <sup>a,b</sup> (11.4)	
	AS + CR	13 <sup>a,b</sup> (4.4)	19 (7.2)	3 <sup>b</sup> (1.9)	10 <sup>c</sup> (17.5)	8 <sup>a,c</sup> (13.6)	
The treatment approach	PCM + ZnOE + Amalgam	67 <sup>a</sup> (22.6)	13 (4.9)	8 <sup>b</sup> (4.9)	3 <sup>b</sup> (5.3)	2 <sup>b</sup> (4.5)	<b>0.009*</b>
	TE + TR	38 <sup>a</sup> (12.8)	21 (7.9)	13 <sup>a</sup> (8.0)	4 <sup>a</sup> (6.8)	4 <sup>a</sup> (9.1)	
	TE + PR	207 <sup>a</sup> (69.9)	169 (63.8)	97 <sup>a</sup> (58.6)	41 <sup>a</sup> (69.5)	33 <sup>a</sup> (75.0)	
	SCR + TR	24 <sup>a</sup> (8.1)	35 (13.2)	28 <sup>b</sup> (17.3)	6 <sup>a,b</sup> (10.2)	1 <sup>a,b</sup> (2.3)	
The most effective situation in deciding that carries close to the pulp removed sufficiently	SCR + PR	27 <sup>a</sup> (9.1)	40 (15.1)	26 <sup>a</sup> (16.0)	8 <sup>a</sup> (13.6)	6 <sup>a</sup> (13.6)	<b>0.01#</b>
	Check with excavator	211 <sup>a</sup> (71.3)	190 (71.7)	119 <sup>a</sup> (73.5)	36 <sup>a</sup> (61.0)	35 <sup>a</sup> (79.5)	
	Color&Dentine consistency	79 <sup>a</sup> (26.7)	59 (22.3)	38 <sup>a</sup> (23.5)	17 <sup>a</sup> (25.4)	6 <sup>a</sup> (13.6)	
Case 1	Guided by caries indicator dye or LF	6 <sup>a</sup> (2.0)	16 (6.0)	5 <sup>a</sup> (3.1)	8 <sup>b</sup> (13.6)	3 <sup>a,b</sup> (6.8)	<b>&lt;0.01#</b>
	IPC	172 <sup>a</sup> (58.1)	185 (69.8)	114 <sup>a,b</sup> (70.4)	46 <sup>b</sup> (78.0)	25 <sup>a,b</sup> (56.8)	
	DPC	106 <sup>a</sup> (35.8)	75 (28.3)	47 <sup>a</sup> (29.0)	14 <sup>a</sup> (20.3)	16 <sup>a</sup> (36.4)	
	RCT	18 <sup>a</sup> (6.1)	5 (1.9)	1 <sup>b</sup> (0.6)	1 <sup>a,b</sup> (1.7)	3 <sup>a</sup> (6.8)	
Case 2	IPC	205 <sup>a</sup> (69.7)	203 (76.6)	128 <sup>a</sup> (79.0)	46 <sup>a</sup> (78.0)	29 <sup>a</sup> (65.9)	<b>&lt;0.002*</b>
	DPC	68 <sup>a</sup> (23.1)	59 (22.3)	36 <sup>a</sup> (21.0)	10 <sup>a</sup> (16.9)	15 <sup>a</sup> (34.1)	
	Apexification	21 <sup>a</sup> (7.1)	3 (1.1)	0 <sup>b</sup> (0.0)	3 <sup>a</sup> (5.1)	0 <sup>a,b</sup> (0.0)	

PCM: Pulp Capping Material, DDCLs: Deep Dentine Caries Lesions, MTA: Mineral Trioxide Aggregate, AS: Adhesive System, BD&CEM: Biodentine and Calcium Enriched Mixture, CR: Composite Resin, GIC: Glass Ionomer Cement, ZnOE: Zinc Oxide Eugenol, TE: Total Excavation, SCR: Selective Caries Removal, TR: Temporary Restoration, PR: Permanent Restoration, LF: Laser Fluorescence, IPC: Indirect Pulp Capping, DPC: Direct Pulp Capping, RCT: Root Canal Treatment

p values are based on the Pearson Chi-Square test and \*, # represents the statistically significant difference (p<0.05). The \*p-value represents the statistical difference between general dentists and specialist dentists. The #p-value represents the statistical difference between general dentists and subgroups of specialist dentists. The different lowercase letters (a, b, c) represent the statistical difference between the groups on the same line.

treatments reported response rates falling between 25% and 68%<sup>14, 15</sup>, but an optimum response rate of 70% to 80% is preferable to minimize the risk of bias.<sup>16</sup> The response rate in the current work was 71%.

Most of the participants were female (67.1%), similar to the populations of previous studies<sup>16, 17</sup>, and were aged 25 to 35 years (73.3%) (Table 2). Considering the

associations between the local work practices of dentists and variables related to the procedures employed to treat DDCLs, Dycal was the most frequently used PCM in the universities, ODHC, and PC. However, it was not considered the most successful material. The results of the present study are in accordance with those of Chisini et al.<sup>11</sup> and Javaid et al.<sup>18</sup> wherein the majority of the respondents reported Dycal as their first choice for

direct and indirect pulp capping. Whereas Dycal was regarded as the most effective PCM by the GDs and specialists working in the ODHCs, MTA was evaluated more favorably by the university and PC dentists. The difference between the groups in this respect was significant ( $p < 0.05$ ). Despite its clinical success, the most common reasons for the dismissal of MTAs by the dentists included cost, a lengthy hardening time, requires multiple sessions and difficulties in application.<sup>11</sup> Most of the participants from all the institutions (ODHC, PC, and universities) expressed a preference for total excavation with a subsequent application of a permanent restorative material. However, 47.6% of them leaned toward placing a GIC on a PCM and completing treatment with a composite resin. Nevertheless, the analysis based on specialization uncovered that 35.1% of the RDs, 43.2% of the GDs, 50% of the EDs, and 59.3% of the PDs preferred to use PCM + GIC before using a composite resin. There are studies in the literature suggesting that the use of cavity base material would have a weakening effect and increase failure in composite restorations.<sup>19,20</sup> Li et al.<sup>21</sup> stated that the bond strength of glass ionomer cement to composite resin is limited due to the low cohesive strength. RDs' preference for GIC use is considered to be low due to the reasons mentioned above. The PDs and EDs might have preferred to use GIC at a high rate in order to avoid the adverse effect on pulp vitality of the residual monomer released after composite resin polymerization. Although this procedure was generally preferred among the survey respondents, previous studies reported contrasting inclinations. A systematic review uncovered that the treatment of DDCLs does not depend on drugs, but a more recent systematic evaluation presented contradictory results regarding the use of primers for postoperative sensitivity under resin-bonded restorations.<sup>22</sup> In a similar work, conflicting findings were derived concerning the use of liners under resin-bonded restorations to address postoperative sensitivity.<sup>23</sup>

Visual and tactile decision is a subjective method for the diagnosis of residual caries. Objective methods, such as the use of caries detector dyes and Laser Fluorescence (LF), have also been used in recent years. Because these approaches entail extra cost and time, clinicians generally prefer traditional methods. The present study results showed that the dentists frequently use excavators to check for the presence of caries at the base of a cavity. This finding agrees with the results reported in previous studies.<sup>24,25</sup> Caries indicator dye or LF was most commonly used by RDs. The current research also discovered that the dentists reached no consensus as to the proposed terminology for the removal of carious tissues.

Among the participants, 66.7% of those who graduated less than 10 years previously and 57.3% of those who graduated more than 10 years ago apply IPC treatment

to permanent teeth with DDCLs to avoid pulp exposure (Table 4). The difference between the groups was significant ( $p < 0.05$ ). Many studies have reported that time elapsed since graduation is an important factor for issues in clinical diagnosis, material selection, and treatment strategy.<sup>16,26</sup>

Research has also shown that dentists adopt differing attitudes concerning clinical decision making even when they encounter the same clinical situation. These differences are regarded as natural variations in the clinical decision making process, but such inconsistencies have also encouraged the development of guidelines aimed at reducing variations and ensuring appropriate quality of care. These developments prompted us to encompass both specialists and GDs in the current study. The results (Table 5) revealed that these two groups differed significantly in terms of material selection, treatment approaches, and decision-making methods in the treatment of DDCLs ( $p < 0.05$ ). The null hypothesis was thus invalidated.

Although Dycal emerged as the most used pulp capping material, MTA was used more frequently by the PDs and EDs (Table 5). Finnish guidelines published in June 2016 recommend the adoption of MTA for a PCM if a mature tooth is vital and asymptomatic as pulp is exposed during caries removal.<sup>27</sup> The present study results were in accordance with those of Li et al.<sup>16</sup>, who also reported that MTA is the most commonly used material for the treatment of DPC and partial pulpotomy. However, these authors stated that EDs more strongly prefer performing a DPC than do GDs and using calcium silicate materials, such as Theracal, for vital pulp therapy.

Clinical cases enabled us to learn about possible treatment approaches of general and specialist dentists. Clinical case #1 illustrated the theoretical background in treatment planning for deep-carious mature permanent teeth. The aim was to evaluate the management preference of GDs and specialist dentists. Interestingly, the majority of participants chose the IPC treatment protocol option. In vital and asymptomatic occlusal carious teeth, leaving affected dentin might protect the pulpal health and could arrest caries progression. Selective caries removal was seen to be more preferred by PDs. Although complete removal of caries is a basic principle in dentistry, it may endanger the viability of the pulp by causing possible pulp perforation. There was no difference between general and specialist dentists in this preference. Root canal treatment option, which is a radical treatment approach for this case, was at least preferred by PDs and RDs. It can be said that physicians in these two specialties approach deep dentine caries more conservatively than general dentists and endodontists. Clinical case #2 aimed to assess the management of a deep lesion in a immature permanent teeth.

Apexogenesis would allow continued root development along the entire root length by maintaining pulp vitality.<sup>28</sup> In this context, there was no difference between IPC and DPC treatment options between general and specialist dentists. It was seen that more participants preferred conservative treatment for immature teeth. However, apexification was most preferred by general dentists, which is a radical treatment option for immature teeth.

The PDs in the present research expressed the highest preference for selective caries removal (54%). Koopaei et al.<sup>3</sup> compared GDs, PD, and EDs in terms of treatment strategies, clinical decisions and diagnostic methods, knowledge, attitudes, and behaviors concerning the treatment of DDCLs. They concluded that PDs (31%) are more likely than GDs (12%) and EDs (4%) to partially remove carious tissues. In addition, for mature teeth with DDCLs, the PDs in the current work expressed a statistically significantly lower preference for canal treatment than GDs and EDs. For immature teeth with DDCLs, however, the PDs exhibited a statistically significantly lower preference for apexification than GDs and RDs. We attribute this finding to protective procedures being more popular in the field of pediatric dentistry.

One of the limitations of this study was the low number of each subgroup. According to the specialties of the dentists in Turkey, the number/percentage basis, there is no official data sharing. Therefore, an evident sample size for subgroups could not be calculated. The second was the low response rate among the RDs and EDs—an issue that may have stemmed from the use of a web-based survey instead of face-to-face administration. Another limitation was that some of the participants did not answer every question. Approximately 1.4% of the questions were unanswered. Finally, the possibility of unreached e-mail addresses of the GDs, and specialist dentists could diminish the generalizability of the results to the Turkish dental population. More survey-based studies should therefore be designed in a way that ensures more participants across a country are reached for an evidence-based investigation of dentists' knowledge, behaviors, and approaches to all other treatments. Shorter and simplified surveys can be prepared to increase the response rate of all questions. In addition, dentists can be reached more easily in scientific congresses and symposiums held.

## CONCLUSION

Even with the limitations of this study, parameters such as age, the time elapsed since graduation, place of work, and the number of patients seen per day were identified as influencing factors for the conservative approaches and material preferences of dentists concerning deep dentine carious lesions. Post-graduate education

and specialization play a role in this difference. It is recommended to establish a common treatment protocol for dentists with complementary training in caries management.

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