



# Dentists' awareness and clinical implications of minimally invasive endodontics: A survey study

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**Purpose:** Minimally invasive endodontics (MIE) is a contemporary concept aiming to maximize tissue protection without compromising treatment outcomes. This survey study assessed the awareness and implication of MIE among dentists in Turkey.

**Methods:** A digitally conducted survey was delivered to the dentists electronically. They were enquired about their demographic characteristics, awareness of the MIE and its clinical application; their approach to pulp exposure; access cavity and instrument systems preference; the preparation size and taper choice; and whether they used an additional irrigation protocol and a magnification system. The data were statistically analyzed using Chi-square and Fisher's exact tests. The statistical significance was set as  $p < 0.05$ .

**Results:** 63.5% were aware of MIE, but only 31.2% applied it routinely. Endodontists' and less experienced participants' awareness was significantly higher ( $p = 0.000$ ). During pulp exposure, in the absence and presence of spontaneous pain, 77.9% chose direct pulp capping and 81.4% root canal treatment, respectively. 56.8% preferred traditional and 42.3% conservative access cavities. The most preferred preparation sizes were #30/0.06, #25/0.06 and #30/0.04 for single-rooted, #25/0.06, and #25/0.04 for multi-rooted teeth. 45.7% activated the irrigant, and 27.5% used a magnification system.

**Conclusion:** MIE-performing participants more frequently preferred vital pulp therapies, conservative access, and using a loop.

**Keywords:** Endodontics, minimally invasive, survey.

## Introduction

Over the last few decades, in parallel with significant advances in various fields of technology, medical practices, including dentistry, have begun to adopt a minimally invasive approach that maximizes tissue preservation without compromising treatment outcomes (1,2). The endodontic practice is mainly based on diagnosing, preventing, and treating diseases and injuries of the pulp and pulp-related periradicular tissues (3). As a manifestation of the mini-

mally invasive concept in endodontics, it is aimed at maintaining tooth vitality by preventing pulpal pathoses and apical periodontitis; to treat those that have already developed while preserving maximum structural integrity and function of the tooth (4,5). Therefore, minimally invasive endodontics (MIE) focuses on a series of tissue-respecting approaches, beginning from the treatment decision to minimal but purposeful preparation of the access cavities to preserve as much sound dentin as possible during root

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canal shaping and final coronal restoration (1,2,6).

The assessment of the inflammatory status of the pulp is primarily based on a detailed history of pain, such as previous pain in the same tooth or spontaneity of pain, as well as pulp vitality tests and high-quality radiography techniques (7,8). Irreversible pulp damage is characterized by spontaneous, radiating pain that persists after the stimulus is removed, whereas reversible pulpitis is either asymptomatic or less intense, shorter-lasting pain (7). Conventionally, vital pulp therapy (VPT) applications such as indirect and direct pulp capping and partial or complete pulpotomy were recommended for teeth with reversible pulpitis or teeth with mechanical and traumatic pulp exposure (7,8,9). On the other hand, non-surgical root canal treatment was preferred for most teeth diagnosed with irreversible pulpitis (5,10). However, morphological changes suggesting inflammation or necrosis are mainly confined in the coronal pulp, while the radicular pulp maintains its vitality (10).

After years of traditional access cavities without modification (11,12) Clark and Khademi (13) have introduced the idea of preparing more conservative endodontic access cavities with less dentin removal and more pericervical dentin preservation. More recently, new minimally invasive access cavities of various sizes have been described and advocated, aiming to enhance the fracture strength of the tooth (12,14,15). Depending on the amount of tissue removal, they are basically defined as Conservative access cavities (CAC) or Ultra-CAC, also called “Ninja Access or Truss access” (16). Over time, this approach was extended to protect the root canal dentin, and less tapered instruments were launched (1,15). Nevertheless, MIE applications are unlikely to be realized without utilizing three-dimensional imaging systems, additional irrigation strategies, and visual magnification (1,2). However, there is still neither scientific consensus on the protocol to be followed during minimally invasive endodontic procedures, nor is there any information about dentists’ approach to this concept. Therefore, this survey study aimed to assess the awareness of MIE among dentists in Turkey and the implication level of the concept to their clinical practice.

## Materials and Methods

Ethics committee approval of this cross-sectional questionnaire-based study was granted by the ethics committee of Okan University (2021/143). In the power analysis (G\*Power 3.1; Heinrich-Heine-Universität Dusseldorf, Germany), the minimum number of responses to be taken was determined as 347 based on the data of a previous survey study (17), with a 95% confidence interval, test power of 0.95, and an effect size of 0.211. The question-

naire was conducted through an internet platform (www.googleforms.com) and tested with a pilot group involving 20 dentists. The survey link was sent electronically to active members through the National Dental Association database. Access to the survey link was limited between November 18, 2021 and January 18, 2022. Participation was voluntary and anonymous. Respondents were not asked their names and were not directed to the survey questions unless they agreed to participate. The survey consisted of information explaining the purpose of the study and a total of 14 questions. The first three questions enquired about the participants’ demographic characteristics, such as gender, age, and years of professional experience (Table 1). In the following questions, participants were asked to answer questions about their awareness of the MIE concept; whether they practiced it clinically; their approach to pulpitis cases in pulp exposure; their endodontic access cavity and instrument system preferences; the factors affecting their instrument choice; the preparation size and taper choice during shaping; whether they utilized an additional protocol to traditional irrigation and used a magnification system (Table 2).

Statistical analysis was performed using SPSS Version 23.0 (IBM SPSS, Inc., Chicago, IL, USA). Frequency distributions and percentages were given as descriptive statistics. Categorical variables were carried out using Chi-square and Fisher’s exact tests. Multinomial regression analyses were performed for years of professional experience and specialization. The statistical significance level was set at  $p < 0.05$ .

## Results

A total of 499 responses were received, 91.4% from general dental practitioners (GDPs) and 8.6% from endodontists. Table 1 shows the demographic characteristics of

**Table 1.** Distribution of demographic characteristics of the participants as number (n) and frequency (%)

Demographic features	n (%)	p-value
Gender		
Female	260 (52.1)	0.347
Male	239 (47.9)	
Professional experience		
0–10 years	152 (30.5)	0.051
11–30 yeras	155 (31.1)	
>30 years	192 (38.5)	
Type of practice		
Endodontist	43 (8.6)	0.000*
General dental practioner	456 (91.4)	

\* $p < 0.05$  indicates significant difference.

the participants. The responses of the participants to the survey questions are shown in Table 2. Although 63.5% were aware of MIE, only 31.2% have routinely practiced the minimally invasive approach, while 20.2% have never practiced it. The awareness of participants with less profes-

sional experience was significantly higher ( $p = 0.000$ ). Although endodontists' awareness of MIE was significantly higher than GDPs ( $p = 0.000$ ), regarding the clinically performing rate of MIE, the difference was insignificant ( $p > 0.05$ ).

**Table 2.** Survey questions, and distribution of answers according to type of practice and professional experience

Questions	Answers	Type of practice		p-value	Professional experience			p-value
		Endodontist	GDPs		0–10	11–30	>30	
Are you aware of MIE concept?	Yes	42 8.4%	275 55.1%	0.000*	118 23.6%	101 20.2%	98 19.6%	0.000*
	No	1 0.2%	181 36.3%		34 6.8%	54 10.8%	94 18.8%	
Are you practicing MIE clinically?	Always	11 3.50%	88 27.8%	0.075	33 10.4%	33 10.4%	33 10.4%	0.205
	Never	14 4.4%	50 15.8%		32 10.1%	15 4.7%	17 5.4%	
	Sometimes	17 5.4%	137 43.2%		53 16.7%	53 16.7%	48 15.1%	
What is your treatment option if the pulp exposes in the absence of spontaneous pain?	Direct pulp capping	35 11%	212 66.9%	0.332	98 30.9%	80 25.2%	69 21.8%	0.170
	Pulpotomy	3 0.9%	13 4.1%		6 1.9%	3 0.9%	7 2.2%	
	Root canal treatment	4 1.3%	50 15.8%		14 4.4%	18 5.7%	22 6.9%	
What is your treatment option if the pulp exposes in the presence of spontaneous pain?	Direct pulp capping	3 0.9%	17 5.4%	0.618	7 2.2%	2 0.6%	11 3.5%	0.108
	Pulpotomy	7 2.2%	32 10.1%		14 4.4%	12 3.8%	13 4.1%	
	Root canal treatment	32 10.1%	226 71.3%		97 30.6%	87 27.4%	74 23.3%	
What is your endodontic access cavity preference?	Traditional	16 5%	164 51.7%	0.017*	70 22.1%	44 13.9%	66 20.8%	0.002*
	Conservative	26 8.2%	108 34.1%		47 14.8%	57 18%	30 9.5%	
	Ultra conservative (Ninja)	0 0%	3 0.9%		1 0.3%	- -	2 0.6%	
If given a chance, which system do you prefer for root canal preparation?	ProTaper Universal	3 0.9%	59 18.6%	0.241	12 3.8%	19 6%	31 9.8%	0.006*
	TruNatomy	7 2.2%	13 4.1%		14 4.4%	6 1.9%	- -	
	Wave One Gold	2 0.6%	32 10.1%		13 4.1%	13 4.1%	8 2.5%	
	Reciproc	5 1.6%	48 15.1%		24 7.6%	16 5%	13 4.1%	
	ProTaper Next	14 4.4%	69 21.8%		30 9.5%	31 9.8%	22 6.9%	
	XP-Endoshaper	4 1.3%	8 2.5%		4 1.3%	5 1.6%	3 0.9%	
	Mtwo	1 0.3%	8 2.5%		2 0.6%	3 0.9%	4 1.3%	
	BioRace	0 0%	6 1.9%		2 0.6%	1 0.3%	3 0.9%	
	SAF	1 0.3%	4 1.3%		4 1.3%	- -	1 0.3%	
	EndoExpress	1 0.3%	23 7.3%		3 0.9%	- -	3 0.9%	
	Other	4 1.3%	5 1.6%		10 3.2%	7 2.2%	10 3.2%	

What is your most important expectation from the system you use for root canal preparation	Reduced preparation time	10 3.2%	109 34.4%	0.071	32 10.1%	37 11.7%	50 15.8%	0.003*			
	Maintenance of original canal form	32 10.1%	160 50.5%		82 25.9%	62 19.6%	48 15.1%				
	Being cheap	0	6 1.9%		4 41.3%	2 0.6%	-				
Which preparation size and taper do you prefer for single-rooted teeth?	#25/.04	1 0.3%	29 9.1%	0.000*	8 1.3%	18 2.5%	5.7%	0.000*			
	#25/.06	5 1.6%	59 18.6%		21 6.6%	19 6	24 7.6				
	#30/.04	3 0.9%	58 18.3%		12 3.8%	24 7.6%	25 7.9%				
	#30/.06	6 1.9%	70 22.1%		27 8.5%	32 10.1%	17 5.4%				
	#35/.04	4 1.3%	13 4.1%		10 3.2%	5 1.6%	2 0.6%				
	#35/.06	1 0.3%	10 3.2%		5 1.6%	-	6 1.9%				
	#40/.04	13 4.1%	14 4.4%		16 5%	8 2.5%	3 0.9%				
	#40/.06	9 2.8%	22 6.9%		23 7.3%	5 1.6%	3 0.9%				
	Which preparation size and taper do you prefer for multi-rooted teeth?	#25/.04	11 3.5%		86 27.1%	0.004*	26 8.2%		31 9.8%	40 12.6%	0.019*
		#25/.06	7 2.2%		100 31.5%		38 12%		36 11.4%	33 10.4%	
#30/.04		8 2.5%	42 13.2%	27 8.5%	13 4.1%		10 3.2%				
#30/.06		8 2.5%	32 10.1%	13 4.1%	17 5.4%		10 3.2%				
#35/.04		3 0.9%	7 2.2%	7 2.2%	2 0.6%		1 0.3%				
#35/.06		0 1.9%	6 -	2 0.6%	1 0.3%		3 0.9%				
#40/.04		3 0.9%	3 0.9%	3 0.9%	3 0.9%		1 0.9%				
#40/.06		1 0.3%	0	-	1 0.3%		-				
Do you utilize an additional irrigation protocol to conventional irrigation?		Manual dynamic activation	2 0.6%	54 17%	0.000*		27 8.5%	12 3.8%	17 5.4%	0.014*	
		Sonic activation	25 7.9%	22 6.9%			20 6.3%	19 6%	8 2.5%		
	Ultrasonic activation	9 2.8%	22 6.9%	13 4.1%		11 3.5%	7 2.2%				
	Endovac	1 0.3%	5 1.6%	1 0.3%		-	5 1.6%				
	Lasers	1 0.3%	4 1.3%	2 0.6%		3 0.9%	-				
	No additional protocol	4 1.3%	168 53%	55 17.4%		56 17.7%	61 19.2%				
	Do you use a magnification system in treatment?	Loupe	14 4.4%	68 21.5%		0.943	20 6.3%	33 10.4%	29 9.1%		0.029*
		Microscope	4 1.3%	1 0.3%			1 0.3%	3 0.9%	1 0.3%		
No		24 7.6%	206 64.9%	97 30.6%	65 20.5%		68 21.5%				

\*p<0.05 indicates significant difference. GDP: General dental practitioner.

When the pulp was exposed during caries removal, 77.9% chose direct pulp capping, 17% root canal treatment, and 5% pulpotomy in the absence of spontaneous pain. How-

ever, if there was spontaneous pain, 81.4% chose root canal treatment, 12.3% pulpotomy, and 6.3% direct pulp capping (Table 2). A statistically significant relationship has

existed between clinically performing MIE and treatment choices. MIE-performing participants significantly more frequently preferred direct pulp capping in the absence of spontaneous pain and pulpotomy in case of spontaneous pain compared to those who were not performing MIE ( $p = 0.02$  and  $p = 0.045$ , respectively).

The most preferred endodontic access cavity type was the traditional access cavity (TAC) (56.8%), followed by the CAC (42.3%). Only 0.9% of respondents preferred UCAC (Table 2). Endodontists generally preferred CAC, while GDPs preferred TAC ( $p = 0.017$ ). The MIE-performing respondents significantly more often preferred CAC and using a loop ( $p = 0.000$  and  $p = 0.001$ , respectively) than those who were not performing MIE.

Regardless of professional experience and specialization, if given a choice, the participants would most prefer to use Protaper Next (26.2%), Protaper Universal (19.6%), and Reciproc (16.7%). The association between the instrument choice and the use of an additional irrigation protocol or magnification was insignificant ( $p = 0.694$ ,  $p = 0.864$ , respectively). There was also no significant relationship between the most important expectation in root canal treatment and the preferred taper/size for single and multi-rooted teeth ( $p = 0.284$ ,  $p = 0.279$ , respectively). However, this relationship was significant with the preferred instrument ( $p = 0.013$ ). While most respondents who answered "maintenance of the original canal form" preferred Protaper Next, those who answered "reduced preparation time" preferred Protaper Universal.

There was no significant relationship between performing MIE and preferred instrument system or preparation size/taper in single and multi-rooted teeth ( $p = 0.119$ ,  $p = 0.235$ , and  $p = 0.301$ , respectively). The most preferred preparation sizes were #30/0.06 (24%), #25/0.06 (20.2%), and #30/0.04 (19.2%) for single-rooted teeth, while #25/0.06 (33.7%) and #25/0.04 (30.6%) for multi-rooted teeth, respectively. However, endodontists and GDPs significantly chose different apical sizes and tapers for single and multi-rooted teeth ( $p = 0.000$ ,  $p = 0.004$ , respectively). Endodontists mostly preferred #40/0.04 for single-rooted and #25/0.04 for multi-rooted teeth, while GDPs preferred #30/0.06 for single-rooted and #25/0.06 for multi-rooted teeth.

The number of respondents utilizing an additional irrigation protocol to traditional irrigation was recorded as 45.7%, while those using a magnification system were 27.5%. Endodontists used sonic activation, while GDPs most often preferred gutta-percha activation. The use of an additional irrigation protocol and magnification was also related to endodontic access cavity preference. The rate of not using an additional irrigation method and mag-

nification was significantly higher among the participants who preferred TAC preparation ( $p = 0.027$  and  $p = 0.002$ , respectively).

## Discussion

MIE is a new concept encompassing a systematic approach to benefit patients (15). Although the aim is to preserve natural tissues at all stages of treatment, including the treatment selection (4), there has yet to be a clear protocol for clinical practice.

Our results showed that 63.5% of participants were aware of the MIE. This may be because the majority had less than 30 years of professional experience. Indeed, respondents with less professional experience had significantly higher awareness. However, even though they were aware of MIE, only 31.2% practiced it routinely and 48.6% occasionally. 20.2% chose not to practice MIE at all, without any significant difference between endodontists and GDPs. The lack of a definitive guideline may discourage respondents from implicating this concept in their daily practice. On the other hand, the low frequency of daily endodontic treatment and not following current developments may be the reasons for not practicing MIE.

In accordance with the minimally invasive concept, VPT applications are promoted instead of root canal treatment, even in cases of carious pulp exposure (9). Depending on pulp tissue preservation, the pulp's physiologic and defensive functions can also be maintained (10). Moreover, fracture resistance can be achieved with minimal removal of tooth structure (10,18). Our findings revealed that the participants most frequently preferred direct pulp capping when the pulp was exposed in the absence of spontaneous pain and root canal treatment when it was exposed in the presence of spontaneous pain (Table 2). A recent study has shown that even curiously-exposed teeth with clinical symptoms and spontaneous pain, indicating irreversible pulpitis, may have recovery potential following complete pulpotomy (19). Consistent with this result, it was observed that participants who were practicing MIE had higher rates of VPT applications regardless of the presence of spontaneous pain. This finding can be interpreted as the participants who applied MIE thoroughly understanding the logic behind this concept regarding pulp preservation.

Ensuring adequate endodontic access during root canal treatment is vital for efficient negotiation of the canal orifices, accurate working length determination, chemomechanical preparation, and obturation (20). However, with advances in imaging, endodontic instrument, and magnification systems, the need for traditional endodontic access cavity preparation has diminished (14) and has been replaced with more conservative cavities (11,12). Several



studies have shown that CAC increased fracture resistance compared to TAC (11,12), while others show no advantage of CAC (2,14,21,22). Among our respondents, the most preferred endodontic access cavity was the TAC (56.8%), followed by the CAC (42.3%). The fact that the participants were predominantly GDPs and the relatively small number of participants who routinely performed MIE (31.2%) may have led to this result.

On the other hand, endodontists and MIE-practicing participants were more likely to choose CAC, suggesting that they are more engaged with current developments and better fulfill the requirements of the concept. Tsotsis et al. (23) recently reported that dentists with more than 25 years of experience preferred the TAC design, while those with less than 10 years preferred the CAC. In line with these results, our participants with more than 30 years of professional experience mostly prefer TAC, while those with less than 30 years prefer CAC (Table 2). Only three respondents chose the UCAC design. This may be due to discouraging data that showed UCAC does not play an effective role in fracture resistance (2,21,22) and prolongs the duration of endodontic treatment by making the pulp chamber cleaning difficult (2).

The primary goals of chemomechanical root canal preparation are preserving the original root canal anatomy and complete cleaning of the root canal system by eliminating microbial load and infected/inflamed tissues (1,24). There are various brands of instrument systems on the market. Our participants stated that if they had a choice, they would prefer Protaper Next, Protaper Universal, and Reciproc instrument systems, respectively (Table 2). It was in line with the findings of a previous study that the greatest expectation of the participants from the rotary system was preserving the original canal form, and most of them chose ProTaper Next for this purpose (25).

The optimum size and taper of the root canal preparation are one of the controversial issues in root canal shaping. Considering the participants' instrument choices, it is conceivable that they preferred larger tapered preparations ranging from 0.06 to 0.08. However, their apical size and taper preferences were somewhat different than expected (Table 2). They mostly preferred #25/0.06, #30/0.04, and #30/0.06 for single-rooted teeth, and #25/0.04 and #25/0.06 for multi-rooted teeth. Considering that greater tapered instruments cause a greater dentin loss in the root canal, especially in the pericervical area, preparations with an apical diameter of 0.2–0.4 mm and a taper of < 0.06 were suggested (2,26,27). Regarding shaping ability and fracture resistance, 0.03 and 0.05 tapered canal preparations were reported to have no significant difference (21). In agreement with these statements, endo-

dentists mostly chose a 0.04 taper and an apical size of 40 for single-rooted teeth and 25 for multi-rooted teeth. In comparison, GDPs preferred a 0.06 taper and 30 for single and 25 for multi-rooted teeth.

Although compatible with the principles of MIE, canal preparations at small apical diameters and tapers may lead to limited bacterial elimination and root canal disinfection, thus compromising treatment success (1,21,28). Nevertheless, a recent study revealed that root canals prepared to #20 resulted in more pulp remnant and debris than a #40 when irrigated conventionally (syringe+needle). However, when the irrigant was ultrasonically activated, less prepared canals were as clean as the more prepared ones (29). Therefore, the most likely way to achieve clean canals in conservative preparations seems to support irrigation with a particularly active irrigation strategy (1,29). However, the current study results revealed that the total rate of participants utilizing active irrigation was low (Table 2). The fact that participants who preferred TAC had significantly higher rates of not using any activation method may have contributed to this result. However, even among MIE-practicing participants, some did not use activation. This could be attributed to the need for a definitive irrigation protocol for MIE and the relative expense of the equipment used for activation. Indeed, while endodontists mostly used sonics and ultrasonics, GDPs prefer gutta-percha activation, which does not require additional cost.

One of the biggest challenges when using minimally invasive access cavities is the accurate identification of root canals due to the restricted view of the pulp chamber floor (2). Nowadays, the use of magnification devices in endodontics is expanding due to the technical advantage they provide to the user, such as better visualization of the operation field (30). Consistent with this argument, our results showed that MIE-performing participants have a significantly higher rate of loop use. On the other hand, most participants stated that they did not use magnification systems during endodontic treatment (Table 2). Among them, the high number of those who preferred the TAC design may be interpreted as the participants with sufficient vision in the operation field not needing magnification. Moreover, the high cost of magnification systems, especially operating microscopes, may have deterred participants from using these devices routinely (31).

While interpreting these results, it should be remembered that online surveys have some limitations, such as the possibility of incorrect responses due to survey design, question wording, and respondent-related factors. As a characteristic of a survey study, the obtained data is only valid for the period in which the study was conducted and may

change over time. Therefore, further studies with different participant groups and questions are needed to learn more about dentists' knowledge, attitudes, and behaviors on MIE.

## Conclusion

Within the limitations of this study, it can be concluded that dentists in Turkey are somehow aware of the concept of MIE but do not implicate it in their clinical practice routinely. Endodontists are more likely to incorporate MIE than GDPs. However, there were some inconsistencies between participants' statements and actions. The MIE-practicing participants more frequently perform VPT, prefer CAC, and use irrigant activation and magnification systems in accordance with the requirements of the concept. The findings indicate the need for a guideline on the clinical applications of MIE.

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