



## Scientific Research Report

# Does the Endodontic Education Level Affect Decision-Making for Endodontically Treated Teeth With Apical Periodontitis? A Web-Based Survey

Betul Aycan Alim-Uysal<sup>a\*</sup>, Asiye Nur Dincer<sup>a</sup>, Berkan Yurtgezen<sup>b</sup>, Mehmet Burak Guneser<sup>a</sup>

<sup>a</sup> Faculty of Dentistry, Department of Endodontics, Bezmialem Vakif University, Istanbul, Turkey

<sup>b</sup> Student, Bezmialem Vakif University, Istanbul, Turkey

## ARTICLE INFO

Article history:

Available online 19 February 2021

Key words:

Decision-making

Dental education

Endodontics

Endodontic therapy

## ABSTRACT

**Objectives:** The management of endodontically treated teeth with apical periodontitis is debated among clinicians. The aim of this study was to evaluate treatment choices for endodontically treated teeth with different sizes of periapical lesions among endodontists, endodontics postgraduate students, general dental practitioners, and undergraduate students who had fulfilled their theoretical and clinical training in endodontics.

**Materials and Methods:** Periapical lesion images (no periapical lesion and 1-mm, 3-mm, and 5-mm periapical lesions) were formed on 4 different radiographs with a software program, and the survey included 16 radiographs that were emailed to 1881 participants. Treatment options included extraction, surgical or nonsurgical retreatment, and wait and see. The  $\chi^2$  test was used to compare the responses of the participants.

**Results:** The survey was returned by 1039 participants (55.23%). There were statistically significant differences among the responses of all participants for all cases ( $P < .05$ ), except a case with a broken file and no lesion ( $P = .918$ ). All participants decided to extract at an increased size from a 1-mm periapical lesion to a 5-mm periapical lesion. At all lesion sizes, general dental practitioners planned retreatment less when compared with other groups.

**Conclusions:** This survey study showed that there was a positive correlation between endodontic education level and retreatment decision-making. Dentists who confront seemingly hopeless endodontically treated teeth such as an instrument fracture, a missing canal, or a large periapical lesion should consult with an endodontist before making the decision to extract the tooth.

© 2021 The Authors. Published by Elsevier Inc. on behalf of FDI World Dental Federation.

This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

## Introduction

Apical periodontitis (AP) is an inflammatory disease of periradicular tissues caused by microbial infection within the root canal system.<sup>1</sup> The goal of endodontic treatment is to prevent or heal AP.<sup>2</sup> There is a consensus that the persistence of AP after root canal treatment presents a more complex aetiological and therapeutic situation than AP affecting teeth that have not undergone endodontic treatment.<sup>3</sup> Therefore, the process of decision-making regarding the management of persistent AP could be more difficult for clinicians than the

management of AP affecting teeth not endodontically treated.<sup>3,4</sup>

Periapical radiographs provide a cost-effective, high-resolution image; they are still the most popular method of imaging today<sup>5</sup> and have been commonly used to evaluate the size of periapical lesions.<sup>6</sup> The healing in the bone around a root with AP is generally expected to be observed radiographically at the end of the first year.<sup>7</sup> A significant majority of endodontic lesions are expected to heal completely within 4 years of treatment, and lesions persisting beyond that time are widely regarded as evidence of persistent disease.<sup>7</sup> If a failed root canal treatment occurs, options may include nonsurgical or surgical retreatment, extraction, or follow-up.<sup>8</sup>

There is a high interindividual variation among practitioners in terms of their clinical management of periapical

\* Corresponding author. Faculty of Dentistry, Department of Endodontics, Bezmialem Vakif University, Fatih, Istanbul, Turkey.

E-mail address: [balim@bezmialem.edu.tr](mailto:balim@bezmialem.edu.tr) (B.A. Alim-Uysal).

<https://doi.org/10.1016/j.identj.2021.01.003>

0020-6539/© 2021 The Authors. Published by Elsevier Inc. on behalf of FDI World Dental Federation. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

radiolucencies associated with endodontically treated teeth.<sup>9-11</sup> The praxis concept theory states that varying sizes of periradicular lesions are perceived by dentists as comprising different stages on a continuous health scale.<sup>12</sup> On this scale, there is a cutoff point that is mainly dependent on both personal values and other factors such as cost, the quality of the obturation seal, and the accessibility of the root canal. Thus, practitioners are able to separate the cases that should be retreated from those that should not.<sup>13,14</sup>

There are limited studies in the literature regarding the relationship between endodontic education level and decision-making in hopeless cases.<sup>14-17</sup> It was concluded that endodontists tend more towards retreatment compared with general dentists, and the endodontic educational level could affect the clinician's decision.<sup>15,17</sup> The aim of this survey was to evaluate treatment choices for endodontically treated teeth with differently sized periapical lesions among endodontists, endodontics postgraduate students, general dental practitioners, and undergraduate students.

## Materials and methods

Ethics approval was obtained from the Bezmialem Vakif University Ethics Committee (date: 02.02.2019, decision no: 54022451-050.05.04). This study was in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration. It was carried out using a survey that was sent to endodontists, endodontics postgraduate students, undergraduate students who had fulfilled their theoretical and clinical training in endodontics, and general dental practitioners who had email addresses available through the websites of various universities and public and private hospitals and offices in different cities across Turkey. The survey was pilot-tested among 5 endodontists, 6 general dental practitioners, 4 endodontics postgraduate students, and 6 undergraduate students to evaluate and validate the survey design and participants' level of understanding.

A power analysis was conducted with the program package G\*Power 3.1.2 (University of Duesseldorf) to determine the sample size. An alpha level of 0.05 and a power of 0.80 were assumed when 1-sided tests were used to establish the significance of correlations. The results showed that every group required 96 respondents.

The survey was e-mailed to 1881 participants and was completed by a total of 1039 participants (55.23%) who gave their approval for this study. The survey was emailed through onlineanketler.com (enuvo GmbH) with a cover letter that informed the participants about the study's objectives. The survey was performed over a period of 4 months from February 2019 to May 2019.

Periapical lesion images (no periapical lesion and 1-mm, 3-mm, and 5-mm periapical lesions) were formed on 4 different radiographs with PicsArt software (Softonic International) by 3 endodontists. The responses of all the participants were requested for these radiograph images. The clinical history for all the scenarios was the same. The created scenario involved a 40-year-old male patient with no pain, periodontal problem, mobility, sensitivity of

percussion, and palpation around the relevant teeth. Additionally, all of the patient's root canal treatment was completed 4 years beforehand, and there was no preoperative periapical lesion in this scenario. There was an undetected extra canal and a failed postrestoration in Case 1, an incomplete root canal filling at the distal root and no coronal restoration in Case 2, a fractured crown at the coronal level of the cementodentinal junction and an unexposed root canal filling in Case 3, and a broken file in the mesio-buccal root canal in Case 4 (Figure 1).

Each participant was requested to choose only 1 option for each case from the treatment alternatives presented:

1. Only the completion of coronal restoration, wait and see;
2. Surgical or nonsurgical retreatment; or
3. Extraction.

The responses were entered into SPSS version 22.0 for Windows (IBM Corp.). The frequencies, percentages, and means were calculated to provide an overview of the responses. The  $\chi^2$  test was used to compare the responses of the participants who responded differently to decisions of cases. A significance level of 0.05 was applied to the statistical analysis.

## Results

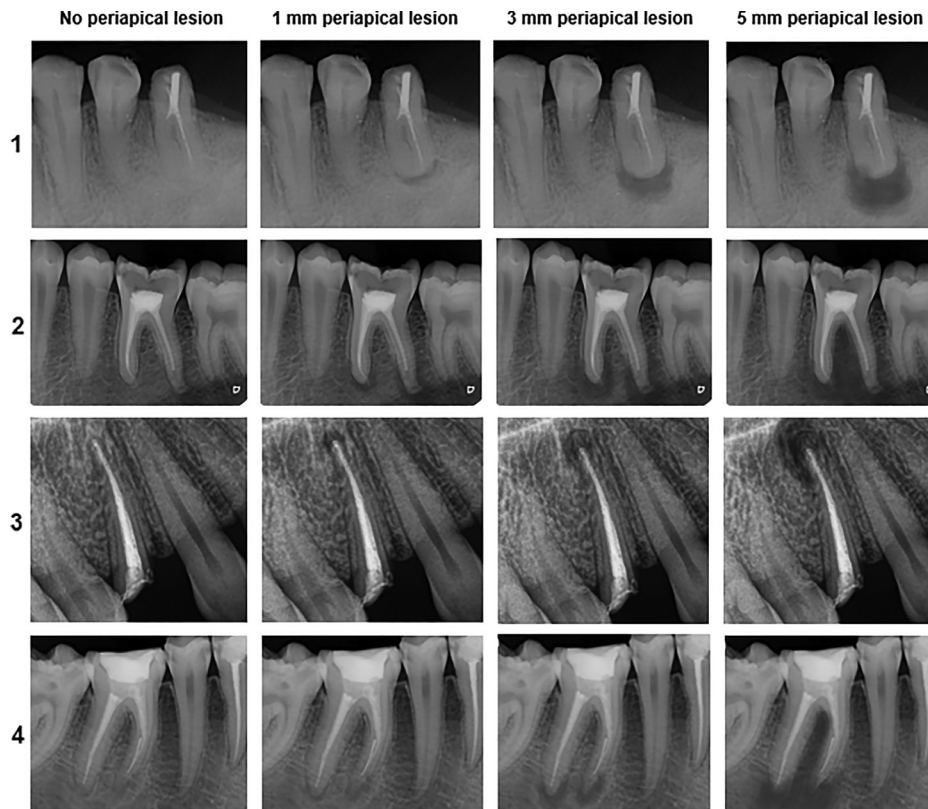
The survey was completed by 1039 participants (55.23%). Of these participants, 337 (32.4%) were male and 702 (67.6%) were female. Concerning their level of education, 126 (12%) were endodontists, 128 (12.3%) were endodontics postgraduate students, 445 (42.8%) were general dental practitioners, and 340 (32.7%) were undergraduate students. With respect to age, 510 (49.1%) participants were in the 20-25 age group; 341 (32.8%) were in the 25-30 age group; 137 (13.2%) were in the 30-40 group; 51 (4.9%) were ages 40 and older.

There were statistically significant differences among the responses of participants for all lesion sizes ( $P < .05$ ) in these cases (Table 1), except for no lesion ( $P = 0.918$ ) in Case 4. Almost 90% of participants preferred the wait-and-see option for Case 4, no lesion (Table 2).

The mean percentages of the extraction, retreatment, and wait-and-see decisions of all participants were calculated. All participants' extraction decisions increased from the 1-mm to the 5-mm periapical lesion. The participants who planned for retreatment at the 1- to 3-mm lesion sizes were more commonly undergraduate students, although endodontists made the retreatment decision more than other groups at the 5-mm periapical lesion size. At all lesion sizes, general dental practitioners planned retreatment less than other groups (Figure 2).

## Discussion

The decision to retreat a root canal is based on the estimation of success or failure of the initial endodontic procedure.<sup>9</sup> The



**Fig. 1 – Images of periapical lesions on 4 different radiographies created by PicsArt software (Softonic International). Case 1: an undetected extra canal and a failed postrestoration; Case 2: an incomplete root canal filling at the distal root and no coronal restoration; Case 3: a fractured crown at the coronal level of the cementodentinal junction and an unexposed root canal filling; Case 4: a broken file in the mesiobuccal root canal.**

endodontic educational level and clinical experience level differences also constitute significant retreatment considerations.<sup>17-19</sup> The primary objective of the present study was to explore decision-making for root-filled teeth with differently sized periapical lesions among 4 groups with different endodontic education levels. We combined both different periapical lesion sizes and difficult clinical situations. To the best of our knowledge, there is no study in the literature that uses a similar methodology.

This study was pilot-tested to eliminate risks of bias by, for example, asking the wrong questions or conducting surveys with the wrong participants. The pilot test validated the survey design and participants' level of understanding. Also, a multiple-choice format was used to prevent confusion. According to the data of the Turkish Dental Association, in 2018, there were 34,045 dentists, including about 800 endodontists and endodontics postgraduate students in Turkey. Although there is a prior Turkish study similar to the present study,<sup>15</sup> the case scenarios, method of creating periapical lesions, and preference of different periapical lesion sizes were more extensively evaluated in the present study. In that study, teeth were chosen based on whether symptoms and a

periapical lesion existed.<sup>15</sup> However, the size of the periapical lesion was not considered.

This study was performed with 1039 participants, and to the best of our knowledge, includes more participants than any of the existing studies in the literature. Since the survey was completely web-based and periapical lesions were formed with a software program, these convenience factors may have elicited a higher response rate from the participants.

Reit and Grondahl<sup>10</sup> found that endodontists had a more optimistic attitude than general practitioners; the endodontists gave higher values to the potential of healing and lower values to the risk of disease progression for the cases they examined. It was also shown that the size of a periapical radiolucency appeared to influence decision-making in relation to endodontic retreatment.<sup>10</sup> In the present study, as the lesion size increased, the probability of deciding on tooth extraction increased in all groups. The probability of deciding on retreatment increased from no periapical lesion to a 3-mm periapical lesion; however, a significant decrease was observed in cases with a 5-mm periapical lesion among general dental practitioners, undergraduate students, and endodontics postgraduate students. Among the endodontists,

**Table 1 – Treatment types selected by all participants according to Case 1 and Case 2 (P < .05).**

CASE 1	US n (%)	EN n (%)	GP n (%)	PS n (%)	P
<b>No lesion</b>					
Extraction	6 (1.8)	2 (1.6)	12 (2.7)	1 (0.8)	.006
Retreatment	160 (47)	80 (63.5)*	192 (43.1)*	64 (50)	
Wait and see	174 (51.2)	44 (34.9)*	241 (54.2)*	63 (49.2)	
<b>1-mm periapical lesion</b>					
Extraction	19 (5.6)	2 (1.6)*	39 (8.8)*	2 (1.6)*	.010
Retreatment	268 (78.8)	101 (80.2)	324 (72.8)*	105 (82)	
Wait and see	53 (15.6)	23 (18.2)	82 (18.4)	21 (16.4)	
<b>3-mm periapical lesion</b>					
Extraction	28 (8.2)*	10 (7.9)*	102 (22.9)*	5 (3.9)*	<.001
Retreatment	306 (90)	111 (88.1)	334 (75.1)*	118 (92.2)*	
Wait and see	6 (1.8)	5 (4)	9 (2)	5 (3.9)	
<b>5-mm periapical lesion</b>					
Extraction	112 (32.9)	18 (14.3)*	221 (49.7)*	24 (18.8)*	<.001
Retreatment	223 (65.6)	106 (84.1)*	216 (48.5)*	101 (78.9)*	
Wait and see	5 (1.5)	2 (1.6)	8 (1.8)	3 (2.3)	
<b>CASE 2</b>					
<b>No lesion</b>					
Extraction	1 (0.3)	1 (0.8)	3 (0.7)	0 (0)	.012
Retreatment	66 (19.4)	43 (34.1)*	88 (19.8)	34 (26.6)	
Wait and see	273 (80.3)	82 (65.1)*	354 (79.5)	94 (73.4)	
<b>1-mm periapical lesion</b>					
Extraction	1 (0.3)*	1 (0.8)	24 (5.4)*	0 (0)	<.001
Retreatment	301 (88.5)*	108 (85.7)	343 (77.1)*	112 (87.5)	
Wait and see	38 (11.2)*	17 (13.5)	78 (17.5)*	16 (12.5)	
<b>3-mm periapical lesion</b>					
Extraction	17 (5)*	3 (2.4)*	99 (22.2)*	4 (3.1)*	<.001
Retreatment	317 (93.2)*	116 (92.1)*	322 (72.4)*	116 (90.6)*	
Wait and see	6 (1.8)	7 (5.5)	24 (5.4)	8 (6.3)	
<b>5-mm periapical lesion</b>					
Extraction	261 (76.8)*	25 (19.8)*	339 (76.2)*	57 (44.5)*	<.001
Retreatment	76 (22.4)*	99 (78.6)*	100 (22.5)*	67 (52.4)*	
Wait and see	3 (0.8)	2 (1.6)	6 (1.3)	4 (3.1)	

EN = endodontist; GP = general dental practitioner; PS = postgraduate student; US = undergraduate student.

\* A significant difference.

76.2% preferred retreatment even if the periapical lesion size was 5 mm. In a previous study, there was a significant difference in the endodontic retreatment planning carried out by more experienced dentists compared to dentists with 5 years or less of clinical experience.<sup>20</sup> In the present study, even in the most hopeless cases, endodontists made more retreatment decisions than endodontics postgraduate students. This is also evidence of the importance of clinical experience and postgraduate education time. The general dental practitioners planned for extraction, which ranged from 2.5% to 64.5% according to the periapical lesion sizes, whereas the endodontists decided on extraction, which ranged from 1% to 21.8%. According to the results of the present study, general dental practitioners planned on extraction more than other groups for all periapical lesion sizes. In previous studies, the healing rate for teeth treated without AP was reported at 88%,<sup>21</sup> 92%,<sup>4</sup> and 97%<sup>22</sup>; however, the healing rate was 74% for teeth with AP.<sup>4</sup> Caliskan<sup>23</sup> examined 75 patients with periapical lesions indicating a failed root canal treatment. The teeth with periapical lesion sizes of 2-18 mm were

retreated. An 80.5% healing rate was observed in patients with a periapical lesion size of less than 5 mm.<sup>23</sup> General dental practitioners could not estimate success rates after endodontic treatment, which might explain why they frequently planned on extraction.<sup>15</sup> In the present study, the general dental practitioners may have assumed that the success rates of implant placement after extraction could be higher than the success rates of retreatment for endodontically treated teeth with AP. Implant placement may also be a high-cost treatment for patients. This could be a positive factor for general dental practitioners making their implant placement decisions if the patient wants the dentist to decide. The undergraduate students preferred to wait and see (69.3%) for no periapical lesion while selecting extraction (56.7%) for 5-mm periapical lesion. Their responses regarding retreatment were similar to those of endodontists and endodontics postgraduate students for 1-mm (80.5%) and 3-mm (88.5%) periapical lesions. This may be because the undergraduate students have made fewer retreatment decisions than other groups and mostly

**Table 2 – Treatment types selected by all participants according to Case 3 and Case 4 (P < .05).**

CASE 3	US n (%)	EN n (%)	GP n (%)	PS n (%)	P
<b>No lesion</b>					
Extraction	5 (1.5)*	1 (0.8)	26 (5.8)*	1 (0.8)	<.001
Retreatment	144 (42.4)*	49 (38.9)	137 (30.8)*	52 (40.6)	
Wait and see	191 (56.1)	76 (60.3)	282 (63.4)	75 (58.6)	
<b>1-mm periapical lesion</b>					
Extraction	7 (2.1)*	5 (4)	55 (12.4)*	1 (0.8)*	<.001
Retreatment	277 (81.5)*	97 (77)	265 (59.5)*	90 (70.3)	
Wait and see	56 (16.4)*	24 (19)	125 (28.1)*	37 (28.9)	
<b>3-mm periapical lesion</b>					
Extraction	34 (10)*	9 (7.1)*	100 (22.5)*	5 (3.9)*	<.001
Retreatment	281 (82.6)*	105 (83.4)*	297 (66.7)*	101 (78.9)	
Wait and see	25 (7.4)*	12 (9.5)	48 (10.8)	22 (17.2)*	
<b>5-mm periapical lesion</b>					
Extraction	143 (42.1)	24 (19)*	235 (52.8)*	24 (18.8)*	<.001
Retreatment	184 (54.1)	98 (77.8)*	195 (43.8)*	96 (75)*	
Wait and see	13 (3.8)	4 (3.2)	15 (3.4)	8 (6.2)	
<b>CASE 4</b>					
<b>No lesion</b>					
Extraction	1 (0.3)	1 (0.8)	3 (0.7)	0 (0)	.918
Retreatment	34 (10)	14 (11.1)	42 (9.4)	11 (8.6)	
Wait and see	305 (89.7)	111 (88.1)	400 (89.9)	117 (91.4)	
<b>1-mm periapical lesion</b>					
Extraction	2 (0.6)*	5 (4)	34 (7.6)*	4 (3.1)	<.001
Retreatment	250 (73.5)*	81 (64.3)	260 (58.4)*	89 (69.6)	
Wait and see	88 (25.9)*	40 (31.7)	151 (34)*	35 (27.3)	
<b>3-mm periapical lesion</b>					
Extraction	26 (7.6)*	10 (7.9)	89 (20)*	11 (8.6)	<.001
Retreatment	300 (88.2)*	104 (82.6)	310 (69.7)*	102 (79.7)	
Wait and see	14 (4.1)*	12 (9.5)	46 (10.3)*	15 (11.7)	
<b>5-mm periapical lesion</b>					
Extraction	255 (75)*	43 (34.1)*	354 (79.6)*	71 (55.5)*	<.001
Retreatment	82 (24.1)*	81 (64.3)*	85 (19.1)*	53 (41.4)*	
Wait and see	3 (0.9)	2 (1.6)	6 (1.3)	4 (3.1)	

EN = endodontist; GP = general dental practitioner; PS = postgraduate student; US = undergraduate student.

\* A significant difference.

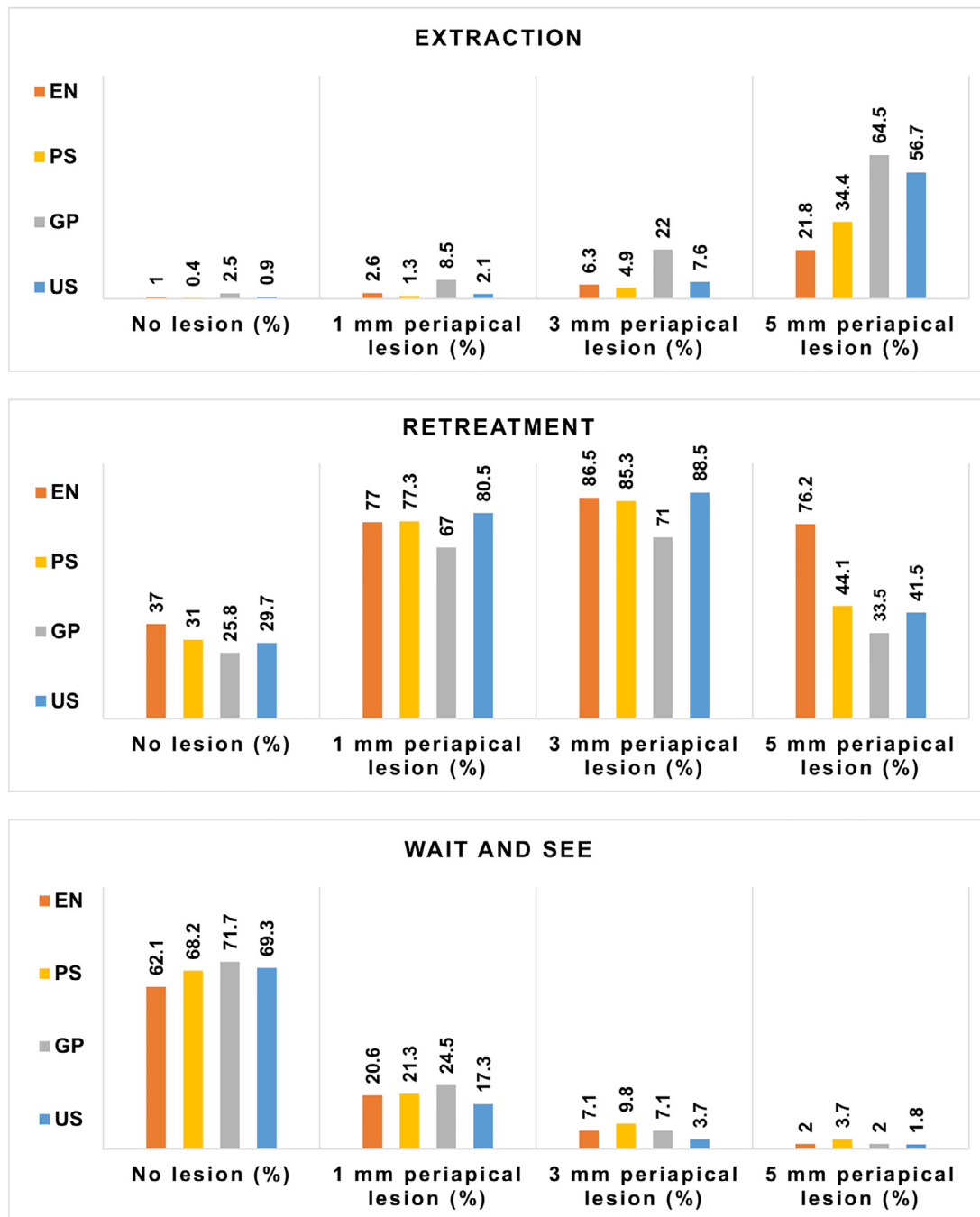
responded to cases by simply using their theoretical knowledge.

A recent retrospective cohort study showed that the prevalence of missed canals was 23.04% and that teeth with a missed canal were 4.38 times more likely to be associated with a lesion.<sup>24</sup> In the present study, there was a missed canal and failed postrestoration in Case 1. Among all cases with 5-mm periapical lesion, this was the case when, at minimum, extraction was planned. We assumed that the participants believed more in healing in this case after the cleaning and shaping of the missed canal than in other cases with the 5-mm periapical lesion.

The coronal restoration significantly affects the success rate of endodontic treatment.<sup>25</sup> In the present study, the development of periapical lesions despite the homogenous root canal filling and requirement of postrestoration after retreatment may have increased the participants' extraction decisions in Case 3.

The instrument fracture in the root canal during previous treatment was also a complication that forced dentists

to take action. It was shown that a higher percentage of students referred to broken file cases, while dentists tried to remove or bypass the broken file.<sup>26</sup> In the present study, more than 80% of all participants preferred the wait-and-see approach in Case 4 if there was no lesion ( $P = 0.918$ ). This decision may have been related to the outcome that the AP did not develop, even though the root canal treatment was performed 4 years ago. In the 5-mm periapical lesion with a broken file, more than 50% of the endodontics postgraduate and undergraduate students and general dental practitioners decided to perform extraction. Furthermore, out of all the cases, this case involved extraction being planned the most by all participants. According to the results of cases with broken files, it was noticed that even if the case did not seem to have a good prognosis, endodontists would attempt treatment before extraction. Among the endodontists, 64.3% preferred retreatment for an endodontically treated tooth with a broken file in the root and for a 5-mm periapical lesion in any case. Endodontists are more experienced in the



**Fig. 2**– The percentage values of the participants according to extraction, retreatment, and wait-and-see decisions. EN = endodontist; GP = general dental practitioner; PS = postgraduate student; US = undergraduate student.

removal of a broken instrument, and these cases may appear to be hopeless for other groups. In the present study, participants were not asked whether the cases with broken instruments were referred to an endodontist. The reason for extraction being decided on so commonly may be the lack of a consultation option.

One of the limitations of this study was that surgical and nonsurgical retreatment were not separate options because the primary aim was retention of the tooth within the mouth.

Therefore, we chose to limit the possible options to extraction, retreatment, and wait and see.

### Conclusion

This study showed that there was a positive correlation between endodontic education level and retreatment decision-making. It is recommended that dentists who confront seemingly hopeless endodontically treated teeth such as an

instrument fracture, a missing canal, or a large periapical lesion should consult with an endodontist before making the decision to extract the tooth in question.

### Funding

None disclosed.

### Conflict of interest

None disclosed.

### Acknowledgements

The authors would like to thank the members of the Turkish Society of Endodontology, general dental practitioners, undergraduate students, and Dr Tolga Yuksel.

### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.identj.2021.01.003](https://doi.org/10.1016/j.identj.2021.01.003).

### REFERENCES

1. Kakehashi S, Stanley HR, Fitzgerald RJ. The effects of surgical exposures of dental pulps in germ-free and conventional laboratory rats. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1965;20:340–9.
2. Ørstavik D, Pitt Ford TR. Apical periodontitis: microbial infection and host responses. Ørstavik D, Pitt Ford TR, editors. *Apical periodontitis: microbial infection and host responses. Essential endodontology: prevention and treatment of apical periodontitis* 1998:1–8.
3. Nair PNR. On the causes of persistent apical periodontitis: a review. *Int Endod J* 2006;39:249–81.
4. Friedman S, Abitbol S, Lawrence HP. Treatment outcome in endodontics: the Toronto Study—Phase 1: initial treatment. *J Endod* 2003;29:787–93.
5. Kundel HL, Revesz G. Lesion conspicuity, structured noise, and film reader error. *AJR Am J Roentgenol* 1976;126:1233–8.
6. Bender IB. Factors influencing the radiographic appearance of bony lesions. *J Endod* 1997;23:5–14.
7. European Society of Endodontology. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. *Int Endod J* 2006;39:921–30.
8. Karabucak B, Setzer F. Criteria for the ideal treatment option for failed endodontics: surgical or nonsurgical? *Compend Contin Educ Dent* 2007;28:391–7.
9. Hulsmann M. Retreatment decision-making by a group of general dental practitioners in Germany. *Int Endod J*. 1994; 27:125–32.
10. Reit C, Grondahl HG. Endodontic retreatment decision making among a group of general practitioners. *Scand J Dent Res* 1988;96:112–7.
11. Petersson K, Lewin B, Hakansson J, et al. Endodontic status and suggested treatment in a population requiring substantial dental care. *Dent Traumatol* 1989;5:153–8.
12. Kvist T, Reit C, Esposito M, et al. Prescribing endodontic retreatment: towards a theory of dentists behavior. *Int Endod J* 1994;27:285–90.
13. Kvist T, Heden G, Reit C. Endodontic retreatment strategies used by general dental practitioners. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2004;97:502–7.
14. Reit C, Kvist T. Endodontic retreatment behaviour: the influence of disease concepts and personal values. *Int Endod J* 1998;31:358–63.
15. Cicek E, Ozsezer-Demiryurek E, Ozerol-Keskin NB, et al. Comparison of treatment choices among endodontists, postgraduate students, undergraduate students and general dentists for endodontically treated teeth. *Int Dent J* 2016;66:201–7.
16. Wenteler GL, Sathorn C, Parashos P. Factors influencing root canal retreatment strategies by general practitioners and specialists in Australia. *Int Endod J* 2015;48:417–27.
17. Pagonis TC, Fong CD, Hasselgren G. Retreatment decisions: a comparison between general practitioners and endodontic postgraduates. *J Endod* 2000;26:240–1.
18. Reit C, Grondahl HG, Engstrom B. Endodontic treatment decisions: a study of the clinical decision-making process. *Endod Dent Traumatol* 1985;1:102–7.
19. Reit C, Grondahl HG. Endodontic decision-making under uncertainty: a decision analytic approach to management of periapical lesions in endodontically treated teeth. *Endod Dent Traumatol* 1987;3:15–20.
20. Nagi SE, Khan FR, Rahman M. Practice of endodontic re-treatment in four cities of Pakistan. *J Ayub Med Coll Abbottabad* 2017;9:445–9.
21. Engstrom B, Hard AF, Segerstad L, et al. Correlation of positive cultures with the prognosis for root canal treatment. *Odontologisk Revy* 1964;15:257–70.
22. Sjogren U, Hagglund B, Sundqvist G, et al. Factors affecting the long-term results of endodontic treatment. *J Endod* 1990;16:498–504.
23. Caliskan MK, Kaval ME, Tekin U, et al. Radiographic and histological evaluation of persistent periapical lesions associated with endodontic failures after apical microsurgery. *Int Endod J* 2016;49:1011–9.
24. Karabucak B, Bunes A, Chehoud C, et al. Prevalence of apical periodontitis in endodontically treated premolars and molars with untreated canal: a cone-beam computed tomography study. *J Endod* 2016;42:538–41.
25. Pedro FM, Marques A, Pereira TM, et al. A status of endodontic treatment and the correlations to the quality of root canal filling and coronal restoration. *J Contemp Dent Pract* 2016;17(10):830–6.
26. Pedir SS, Mahran AH, Beshr K, et al. Evaluation of the factors and treatment options of separated endodontic files among dentists and undergraduate students in Riyadh area. *J Clin Diagn Res* 2016;10:18–23.