

Knowledge and clinical experiences of pediatric dentists and endodontists regarding regenerative endodontic procedures

Regenerative endodontic procedures

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Abstract

Aim: Pediatric dentists and endodontists perform regenerative endodontic procedures (REPs) on immature permanent teeth with necrotic pulp. The aim of this survey was to gather information about the knowledge and clinical experiences of pediatric dentists and endodontists regarding REPs.

Material and Methods: A 23-question survey was formed and a participation link was sent via e-mail. The questions were prepared based on AAE guide. The survey consisted of various types of questions to obtain information about the physicians' age, gender, education information, previous regenerative endodontic therapy (RET) experiences and preferred REPs clinical protocols.

Results: A total of 207 volunteers, 101 pediatric dentists and 106 endodontists participated in the study. RET was chosen by 68.1% of participants as their first choice in incisors, 50.2% in premolars and 40% in molars. The most important criterion is the stage of root development (44.8%) to decide between RET or apexification; 53.5% of the participants learned about REPs during residency training; 70.5% of the participants had applied REPs before (pediatric dentists (77.2%), endodontics (64.1%)). Most of the physicians stated that a candidate suitable for RET in the future would encourage them to practice.

Discussion: The majority of pediatric dentists and endodontists do not adequately follow published standard clinical protocols. However, conducting studies under standard conditions is very important in evaluating the results of clinical protocols. This is very thought-provoking that even specialist physicians who can treat patients in this regard are confused. Therefore, physicians should be informed about this issue and a common protocol should be adopted in treatments.

Keywords

Endodontics, Pediatric Dentistry, Regenerative Endodontics, Surveys, Questionnaires

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Introduction

Regenerative endodontic treatment is a method that has become popular in recent years and can replace traditional endodontic treatment. REPs primarily aim to eliminate the signs/symptoms of the infection, prevent re-infection and provide periapical bone healing [1]. However, unlike traditional endodontic therapy, REPs also aim to get increased root wall thickness and/or increased root length and a positive response to vitality testing. Although, these desirable goals and outcomes have increased the popularity of REPs in recent years (Clinical Considerations for a Regenerative Procedure. Available at: <https://www.aae.org/specialty/publications-research/research/regenerative-database/>) [2], the pertinent literature still includes “many knowledge gaps” [3]. Top cited articles in the literature revealed that researchers are in search for successful protocols to be used for regenerative endodontics [4]. The analysis of clinical procedures for REPs showed that these procedures vary greatly [5]. Also, a systematic analysis of the failed cases remarked the variability of REP protocols despite the American Association of Endodontics (AAE) clinical considerations for a regenerative procedure [6].

A detailed, time and effort-intensive survey is a useful research method to gather information about an individual’s perspective and experiences on a particular issue or topic [7, 8]. Although few surveys pointed out that practitioners generally have positive thoughts, regenerative endodontic therapy is a challenging and confusing issue with its clinical protocols and outcomes [9-12]. From this perspective, the aim of this web-based survey was to gather information about the knowledge and clinical experiences of pediatric dentists and endodontists towards REPs.

Material and Methods

The study was approved by the Inonu University Health Sciences Non-Interventional Clinical Research Ethics Committee (Decision No: 2019/340). A 23-question survey (appendix) was formed using google forms. Forms were sent via e-mail, which contained informative text and a participation link. The questions were prepared based on the AAE guide updated on 4/1/2018 (Clinical Considerations for a Regenerative Procedure. Available at: <https://www.aae.org/specialty/publications-research/research/regenerative-database/>) by two endodontists, a pediatric dentist and a pediatric dentistry resident, and also checked by a biostatistics professor. The first part of the survey gathered information about the age, gender, education and experience of the participants. The second (questions 1 to 10) and third (question 11 to 23) parts of the survey were intended to collect information about previous REPs experiences and the preferred REPs application, respectively. Participants, who did not perform REPs before, skipped questions between 7 and 12. The results were analyzed and presented as percentages [12].

Results

A total of 207 volunteers, 101 pediatric dentists (48.7%) and 106 (51.2%) endodontists, participated in this study. Men accounted for 20% of the participants, 80% of the participants were women, with an average age of 30.80±5.52 years. The distribution of experience period in pediatric dentists according

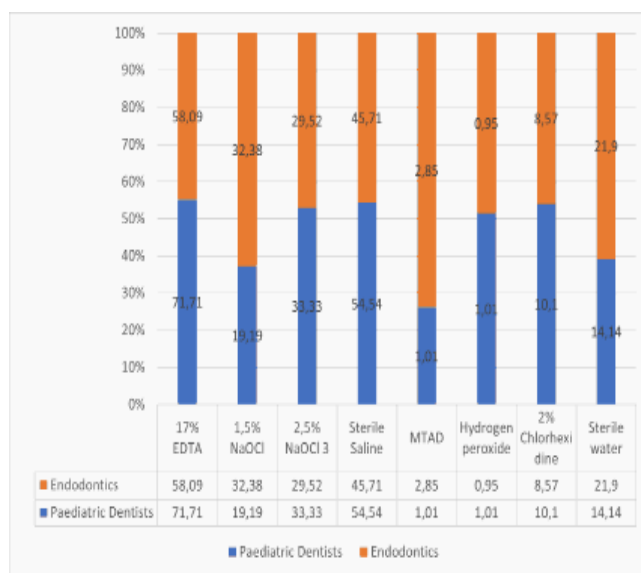


Figure 1. Distribution of 193 answers to question 18. “Which irrigation solution(s) should be used to remove intracanal medicament?”

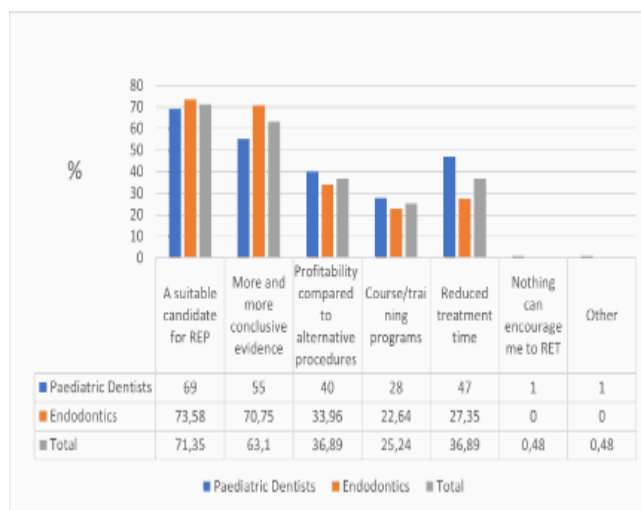


Figure 2. Distribution of 206 answers to question 22. “What will encourage you to practice REPs in the future?”

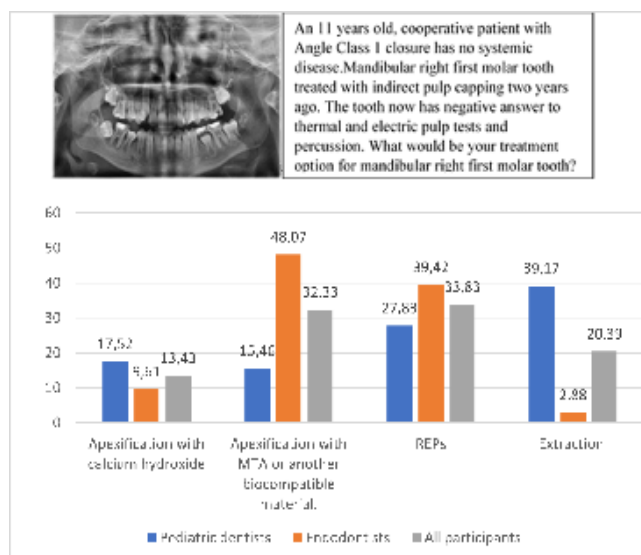


Figure 3. Distribution of 206 answers to question 23.

to the type of specialization was more than 5 years in 32.67% of dentists, 1-5 years in 33.66 % of dentists, less than a year in 11.88%, 21,78% were still residents. Among endodontists, 18.44% had more than 5 years of experience, 26.21% had 1-5 years, 7.76% had less than a year, 47.57% were still residents. "What is your routine treatment approach for immature permanent teeth with necrotic pulp and open apex?" was the first question about the experience (Table 1).

The physicians stated that the most important criterion is the development stage of the root (44.8%), when it is necessary to decide between RET or apexification. These data were 53% for pediatric dentists and 37.1% for endodontists. Also, the second most important criterion for endodontists closest to the first choice was the patient's cooperation (31.4%). Besides, uncooperative patients (63.1%), cases, which require post-core restorations (41.2%) and poor oral hygiene (33.9%) were criteria that discouraged physicians to apply REPs (Table 2).

When asked "What do you think is the most important factor in REP's success?" using a scaffold was the most preferred answer for both pediatric dentists (32.6%) and endodontists (46.2%). In addition, the percentages of all participants' answers were as follows: using a scaffold (39.6%), sterile working conditions (26%), the quality of the restoration (9.1%), provide bleeding (7.7%), the size of the apical diameter (7.2%), using intracanal medicaments (IC) (4.8%), age of the patients (2.4%), minimal or no instrumentation of dentinal walls (1.9%) and systemic condition of the patient (0.9%). Also, most of the pediatric dentists (75.7%) and endodontists (79.6%) think that there is no age limit to apply REP.

When we asked the doctors' methods of obtaining information about REP, 30.61% of pediatric dentists chose "my research and studies", 9.18% chose "AAE guideline", 52.4% chose "during my residency", 4.08% "courses and seminars about REPs", 4.08% "other" chose option; 20% of endodontists chose "research and studies", 14.28% "AAE guideline", 55.23% chose "courses and seminars about REPs", 5.71% "during my residency", 4.76% chose "other" option.

Participants who stated that they had applied REPs before accounted for 70.5% (77.2% of pediatric dentists and 64.1% of endodontics). In addition, answers of the participants about to which teeth that they had previously applied REPs are shown in Table 2. Another data on the previous experiences of physicians were the number of teeth they had applied REPs in a year. The

majority of the participants (59.8%) stated that they applied REPs to 1-3 teeth in a year, 26.5% of them applied REPs to 4-10 teeth, 7.4% applied REPs to 11-20 teeth and 6.1% applied to more than 20 teeth in a year. The percentages of age groups of patients undergoing REPs were 70% for ages between 6-15, 25.8% for ages between 15-18, and 24.4% of patients were older than 18.

The most preferred irrigation solutions used at the first appointment to pediatric dentists were sterile saline (59.7%), 2.5% NaOCl (55.1%), 17% EDTA (40.2%), 1.5% NaOCl (39%) and chlorhexidine (14.9%). The most preferred irrigation solutions for endodontist were 2.5% NaOCl (50.6%), 17% EDTA (48.1%), sterile saline (40.5%), 1.5% NaOCl (40.5%) and chlorhexidine (16.4%). In addition, none of the pediatric dentists marked MTAD, and none of the endodontists marked the hydrogen peroxide.

The rubber dam was definitely used by 87.1% of pediatric dentists and 94.3% of endodontists; 38.8% of the participants (55% of pediatric dentists/23.5% endodontists) stated that no instrumentation should be done, 57.2% (44% of pediatric dentists/69.8% endodontists) required minimal instrumentation and 3.8% (1% of pediatric dentists/6.6% endodontists) reported that it should be done as in routine root canal treatment.

The details of the answers given to the question of IC (intracanal) medicament selection are given in Table 2; 43.2% of the physicians declared that they call patients for a second appointment after two weeks, 26.2% after three weeks, 18.9% after one week, 11.1% after four weeks, and 0.4% after five or more weeks. The approaches of the participants when they detect persistent signs of infection are given in Table 3.

The choice of local anaesthesia in the scaffold formation appointment was important for 67.3% of pediatric dentists and 55.1% of endodontists (Table 3). Physicians preferred to use 17% EDTA (64.7%), sterile saline (50%) and 2.5% NaOCl (31.3%) to remove IC medicament. All answers to this (18th) question are explained in detail in Figure 1. Physicians' answers given to the question of scaffold selection are given in detail in Table 3. If it is not achieved to induce bleeding, 48.4% of the pediatric dentists and 38.6% of the endodontists stated that they would terminate REPs.

The answers regarding the choice of coronary barrier material are given in Table 3. Factors that encourage REP application are given in Figure 2. When asked about the treatment option

Table 1. Knowledge and Clinical Experiences of Pediatric Dentists and Endodontists related to Regenerative Endodontic Procedures: Detailed analysis of answers to Question 1: What is your routine treatment approach for immature permanent teeth with necrotic pulp and open apex?

Choices	Pediatric Dentists			Endodontists			All Participants		
	(% , n)			(% , n)			(% , n)		
	I	P	M	I	P	M	I	P	M
Apexification with Calcium hydroxide	35.64% n=36	37.62% n=38	61.38% n=62	13.20% n=14	11.32% n=12	18.86% n=20	24.15% n=50	24.15% n=50	39.61% n=82
Apexification with MTA or another biomaterial	71.28% n=72	60.39% n=61	36.63% n=37	64.15% n=68	66.98% n=71	67.92% n=72	67.63% n=140	63.76% n=132	52.65% n=109
REP	74.25% n=75	59.40% n=60	52.47% n=53	62.26% n=66	41.50% n=44	27.35% n=26	68.11% n=141	50.24% n=104	39.61% n=82
Extraction	3.96% n=4	4.95% n=5	36.63% n=37	0% n=0	0.94% n=1	5.66% n=6	1.93% n=4	2.89% n=6	20.77% n=43

* Participants can choose more than one option, I: Incisor, P: Premolar, M: Molar.

Table 2. Knowledge and Clinical Experiences of Pediatric Dentists and Endodontists regarding Regenerative Endodontic Procedures. Detailed analysis of answers to questions 3,8,14.

Questions	Choices	Pediatric Dentists (% , n)	Endodontists (% , n)	All Participants (% , n)
* What is/are the patient group/groups for which you do not absolutely apply REP?	Non-padiatric patients	18% n=18	12.26% n=13	14.07% n=29
	Presence of systemic disease	40% n=40	12.26% n=13	25.72% n=53
	Uncooperative patients	57% n=57	68.86% n=73	63.10% n=130
	Patients with a history of allergies	14% n=14	3.77% n=4	8.73% n=18
	Bad oral hygiene	29% n=29	38.67% n=41	33.98% n=70
	Restoration needs with post-core systems	39% n=39	43.39% n=46	41.26% n=85
* Please check which group of teeth you have applied REP before.	Central, lateral	95.65% n=66	80.76% n=63	87.75% n=129
	Canine	10.14% n=7	15.38% n=12	12.92% n=19
	Premolar	55.07% n=38	24.35% n=19	38.77% n=57
	Molar	75.36% n=52	20.51% n=16	46.25% n=68
* Which material/materials should be used as an intracanal medicament?	Should not be used any intracanal medicament	2.97% n=3	3.77% n=4	3.38% n=7
	Double antibiotic paste	59.40% n=60	28.30% n=30	43.47% n=90
	Triple antibiotic paste	50.49% n=51	35.84% n=38	42.99% n=89
	Calcium hydroxide	69.30% n=70	51.88% n=55	60.38% n=125
	Other	0.99% n=1	0.94% n=1	0.96% n=2

* Participants can choose more than one option.

Table 3. Knowledge and Clinical Experiences of Pediatric Dentists and Endodontists towards Regenerative Endodontic Procedures. Detailed analysis of answers to questions 16,17,19,21

Questions	Choices	Pediatric Dentists (% , n)	Endodontists (% , n)	All Participants (% , n)
What do you do when there are signs/symptoms of persistent infection?	I reapply the same intracanal medicament and follow-up.	29.70% n=30	24.52% n=26	27.05% n=56
	I apply a different intracanal medicament and follow-up.	53.46% n=54	57.54% n=61	55.55% n=115
	I terminate REP.	15.84% n=16	17.92% n=19	16.90% n=35
	Other	0.99% n=1	0% n=0	0.48% n=1
Is the choice of local anesthesia important at the scaffold formation appointment?	No	32.63% n=31	44.89% n=44	38.86% n=75
	Other	67.36% n=64	55.10% n=54	61.13% n=118
* What should be used as a scaffold?	Blood clot	93% n=93	79.24% n=84	85.92% n=177
	Platelet-rich plasma (PRP)	62% n=62	66.03% n=70	64.07% n=132
	Platelet-rich fibrin (PRF)	65% n=65	72.64% n=77	68.93% n=142
	Other	5% n=5	3.77% n=4	4.36% n=9
* Which material(s) should be preferred as a coronal barrier?	MTA	92% n=92	95.28% n=101	93.68% n=193
	Glass ionomer	18% n=18	5.66% n=6	11.65% n=24
	Biodentine	57% n=57	67.92% n=72	62.62% n=129
	Endosequence root repair material	11% n=11	19.81% n=21	15.53% n=32
	Other	1% n=1	0% n=0	0.48% n=1

* Participants can choose more than one option.

of a case, the responses were variable. All answers to this (23rd) question are explained in detail in Figure 3. All questions and options are attached in the appendix.

Discussion

Necrotic immature teeth are difficult to treat due to thin dentinal walls and open apex. RET as an alternative to apexification has promising clinical and radiographic outcomes such as continued root development, formation of new vascularized tissue [13]. Still, in the literature, the problem caused by the variability of the clinical protocols of RET is emphasized [2-5]. There is an up-to-date guideline in the published literature called "AAE Clinical Considerations for a Regenerative Procedure", we designed the survey based on this study. Analysis of this survey results indicated that most of the pediatric dentists and endodontists do not follow or pay attention not only to this protocol and any other protocols, but also up-to-date literature of REPs after residency training. Some survey studies on REP showed that 50.6-56.4% of the physicians who participate the surveys had received training before [9-12] and 88-93.5% of them volunteered to receive training on RET [10].

Based on Cvek's classification of root development, stage 1, 2 or 3 (short root, thin canal walls and wide-open apex) is proper for RET, and stage 4 may treat with RET or apexification with MTA as an apical plug [2]. When most of the pediatric dentists (53%) evaluate the root development stage, endodontists evaluate the root development stage (37.4%) and the cooperation of the patient (31.4%) to choose between REP and apexification according to this study results.

The age limit for patients to perform REP is another controversial issue. When Lee et al. asked participants whether there was an age limit for REP, there was a balance between yes (49.8%) and no (49.8%) [12]. In our study, the majority of the participants (78.2%) think that the age of the patient is not an obstacle for RET. Besides, it was stated that the treatment of a middle-aged patient's permanent teeth with open apex with REP was successful [14]. When we asked physicians about the patients' characteristics for who absolutely did not want to apply RET, the most popular answer was uncooperative patients (63%).

REP experiences of physicians were also investigated in different survey studies. The rate of participants who stated that they had applied any type of REP before, varied between 24.5 and 60% [9-12, 15]. According to our results, 77.2% of pediatric dentists and 64.1% of endodontists have previously applied REP. Most of them (59.8%) declared that they applied REP to 1-3 teeth per year. This result is less than the rate (76.9%/ 1-3 teeth per year) of Lee et al. stated in their study [12]. Additionally, in our study, the rate of physicians who applied RET patients ≤ 5 in the last five years is 51.3%, which is consistent with the rate reported by Tong et al (59.5%) [15]. A survey showed that 19.4% of the physicians preferred pulpal regeneration as an optimal treatment for necrotic immature teeth [10]. In this study, the rates were 68.1%, 50.2% and 40% for immature incisors, premolars and molars, respectively. Although, long-term follow-up studies, which evaluate the success of RET did not reveal a difference between tooth groups, there are more case reports of RET success in the literature and the fact that anterior teeth are affected more by

traumatic dental injuries [16,17] may cause more application of REP to the central and lateral teeth.

It is aimed to introduce stem cells, a blood clot scaffold, and bioactive growth factors by providing periapical bleeding [18]. In 2018, it is reported that 75% of pediatric dental specialists and trainees, and 94.3% of endodontists use blood clots as a scaffold [11,12]. In our study, most (85%) of the participants choose blood clots as a scaffold. Additionally, other preferences were PRP (64%) and PRF (68.9%). Besides, the result that 32.6% of pediatric dentists and 46.2% of endodontists think that the success of REP depends on the use of a scaffold may be interpreted as physicians' interest and care to scaffold formation. In accordance with this information, 43.4% of the participants thought to terminate the treatment if there was no bleeding. Another issue in terms of bleeding is the choice of local anesthetic solution. AAE recommends 3% mepivacaine without vasoconstrictor as a local anesthetic solution to induce bleeding (Clinical Considerations for a Regenerative Procedure. Available at: <https://www.aae.org/specialty/publications-research/research/regenerative-database/>). Petrino's study also supports this [19]. The majority of the participants (61.1%) preferred local anesthetic solutions without vasoconstrictor and pediatric dentists (67.3%) paid more attention the choice than endodontists (55.1%).

Our study also tried to make a connection between the success of the RET and isolation of the tooth with a rubber dam. Pediatric dentists (87.1%) and endodontists (94.3%) agreed about the importance of the rubber dam isolation. Besides, 26% of the all participants remarked sterile working conditions as the most important factor for the success of REP. Lin et al. emphasized that a sterile microenvironment is necessary for tissue regeneration [20].

The various methods of irrigation, the use of IC and TAP (triple antibiotic paste) studied for disinfection, these methods have no superiority over each other in terms of treatment outcomes. Since, pertinent literature revealed that the level of disinfection determines treatment outcomes, recommendations about instrumentation of dentin walls in RET should be reviewed [21]. The use of 1.5% NaOCl followed by 17% EDTA can be beneficial and can prevent the negative effect of high concentrations of NaOCl on "survival and differentiation of stem cells of apical papilla" [22]. In this survey, endodontists preferred to use 2.5% NaOCl (50.6%), 17% EDTA (48.1%), and sterile saline (40.5%), while pediatric dentists preferred sterile saline (59.7%), 2.5% NaOCl (55.1%) and 17% EDTA (40.2%). Regarding instrumentation of the dentin walls, while the majority of pediatric dentists (55%) preferred no to apply instrumentation, most of the endodontists (69.8%) preferred minimal instrumentation. However, the findings of a previous study reported that 70.2% of endodontists did not instrument the dentinal walls [12].

A review about antimicrobial therapeutics in RET indicated that TAP continues to maintain its value in terms of its effectiveness in eliminating microorganisms [23]. Besides, Ca(OH)₂ is recommended as an intracanal medication in RET because of its antimicrobial property [2]. In this study, the most preferred IC was Ca(OH)₂ (60.3% of the physicians). However, Lee et al reported a lower percentage (52.2%) for Ca(OH)₂. Systematic

analysis notified that the persistent infection is responsible for 79% of failed RET cases [6]. In the presence of persistent infection, 16.9% of the participants declared that they would terminate RET, while the majority (55.5%) would apply a different IC and follow-up.

In this study, MTA and Biodentin are frequently preferred due to their advantages in treatments [24]. MTA was the most preferred material (93.6%) while Biodentine was the second best (62.6%) for pediatric dentists and endodontists as a coronal barrier.

Participants in different fields of expertise specified RET as a better treatment option when compared to implant application with ratios ranging between 50 and 87.1%. Also, 84.5–96.8% of them volunteered to protect teeth and surrounding tissues [9,10]. In the case question directed to the participants, the majority preferred regenerative and endodontic procedures for tooth preservation instead of extraction (Figure 3). These preventive approaches of physicians are promising for the future of regenerative therapy. Physicians express their needs as more conclusive evidence (63.1%) and having a suitable patient (71.3%) to be encouraged for future REP applications.

Conclusion

Although the literature on REP indicates successful treatment outcomes, pediatric dentists and endodontists are not sufficiently encouraged to prefer regenerative endodontic procedures as the first option for the treatment of immature permanent teeth with necrotic pulp. Therefore, physicians should be given training on REP and the results of the studies should be reported with success and failure, and the literature should be supported.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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