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Perspectives of Endodontists and Pediatric Dentists on Regenerative Pulp Treatments

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Abstract

Objective(s): This study aimed to evaluate and compare the perspectives of endodontists and pediatric dentists on pulp regeneration treatments, the frequency of their use, and their methods of implementation. **Methods:** The study employed a cross-sectional design. The sampling process involved distributing questionnaires to all mentioned specialists practicing in Mashhad in 2023. Chi-Square test was utilized to assess the association between categorical variables with the significance level set at 0.05. **Results:** A total of 67 specialists completed the questionnaires. 50.7% were endodontists, and 49.3% were pediatric dentists. 59.7% of the respondents stated that they had received training in regeneration treatments, 32.3% stated that they incorporate it into their practice. 66.2% of the specialists expressed willingness to participate in regeneration treatment training courses. Of the participants, 58.5% considered it to be successful, and 66.7% believed it to be a superior alternative to dental implants. 44.9% identified high cost as the main barrier to patient acceptance. 62.1% regarded pulp revitalization as the most valuable outcome, and 57.6% agreed that it is the optimal approach for necrotic immature teeth. **Conclusion:** Only 33% of specialists offered regenerative treatment, with over 50% of them utilizing it in less than 10% of their overall treatments. Endodontists were more inclined to provide this treatment compared to pediatric dentists. Most of the experts expressed interest in participating in a training course regarding regeneration.

Keywords: Apexification; Dental Pulp; Endodontics; Regeneration; Tooth Apex; Young Permanent Teeth

Introduction

One of the major challenges in dental treatment involves the management of immature permanent teeth. Despite the presence of a robust defense system, the pulp of a young permanent tooth can still be susceptible to damage from microorganisms or inadequate blood supply due to irritants. This can subsequently lead to the formation of underdeveloped roots, resulting in weakened and thin dentinal walls, as well as blunderbuss apices.[1] Studies have suggested that the use of calcium hydroxide in apexification procedures may pose an increased risk of tooth fractures over time. Specifically, if calcium hydroxide is utilized for a duration exceeding three months, the likelihood of tooth fractures becomes notably significant. In fact, teeth treated with calcium hydroxide for apexification exhibit a higher incidence of fractures and diminished long-term survival. As an alternative treatment approach for teeth with blunderbuss apices, endodontic regeneration can be considered.[1, 2] Since the initial publication on dental pulp regeneration treatment in 2001, over 200 cases have been documented in scientific literature. Despite variations in clinical approaches, certain common trends have emerged, including case selection criteria, disinfection methods, stimulation of bleeding, and restorative techniques.[3]

Clinicians often rely on predetermined criteria, such as the continuous development of roots and pulp test responses, to assess the "success" of regenerative procedures. However, it is important to note that most patients simply desire a pain-free and functional tooth. In reality, a comprehensive approach is essential to accurately evaluate the outcomes of regenerative pulp treatment.[4-7]

As pulp regeneration treatment is a specialized dental procedure primarily performed by pediatric dentists and endodontists, the objective of this study was to investigate the criteria used for case selection, treatment methodologies, assessment of outcomes, and the frequency of performing this treatment among these specialists. After conducting a literature search, it is clear that no similar study has been conducted in this specific area in Iran. Therefore, this study aimed to bridge the existing research gap by investigating various aspects of regeneration treatment among pediatric dentists and endodontists in Iran.

Methods

This research sought to assess and compare the viewpoints of endodontists and pediatric dentists on pulp regeneration treatments, in addition to examining how often and by what methods these treatments are employed. It was designed as a cross-sectional study and included participation from all endodontists and pediatric dentists practicing in Mashhad, Iran in 2023. Epelman's study[8] was referenced as a source to create the checklist for this study. The content and form validity of the checklist were then evaluated by a group of 11 expert endodontists. Additionally, the reliability of the checklist was assessed by means of the internal-consistency method using Cronbach's alpha, that was determined to be 0.72. The content validity of the questionnaire showed that most of the questions with CVR and CVI higher than the acceptable limit of 0.75 and 0.7 were appropriate, except for two questions that were removed due to low CVI and CVR. The impact score of the items was checked by the opinion of eight experts and all the items with an impact above 0.75 were retained. The questionnaires were handed out in person to the participants in written form by a senior dental student. No personal details were included in the questionnaires, and they contained three categories of questions:

1. Professional status: Age, gender, work experience, workplace, participation in training courses, and the frequency
of reading scientific journals.
2. Attitudes and viewpoints on regenerative treatments: Willingness to participate in educational courses, biggest obstacle, most valuable consequence of this treatment, comparison to dental implant.
3. Clinical practice: Frequency of usage, treatment plans, materials used (irrigation, intracanal medicament, coronal seal), costs of the treatment, and referral.

This research study underwent ethical review by the ethics committee at Mashhad University of Medical Sciences and was approved with the code IR.MUMS.DENTISTRY.REC.1400.114. It is important to note that the researchers strictly adhered to maintaining the confidentiality of all participants' information and ensured that it would only be used anonymously for the purposes of this research project.

The sample size estimation was based on a comprehensive census, encompassing all endodontists and pediatric dentists in Mashhad. In this study, The Chi-Square test was utilized to assess the association between categorical variables. Statistical analyses were performed using SPSS software, version 26. The significance level was set at $P < 0.05$ for all tests.

Results

A total of 99 questionnaires were prepared and distributed to the targeted group. Out of these, 67 questionnaires were completed and returned. The non-response rate was attributed to various reasons: 27 individuals lacked interest in participating, 3 individuals had migrated, and 2 individuals had retired or were no longer practicing. The resulting response rate for the study was 67.6%.

Part 1: Professional Status

Table 1 provides the professional status of the specialists involved in the study. The age range of the participants varied from 27 to 56 and above, and their specialized practice duration ranged from 0 to more than 20 years. Regarding their engagement with scientific dental journals, only 6% claimed to have never read them. Furthermore, 59.7% of the participants indicated that they had received training in regenerative dental treatment, with no significant statistical difference between pediatric dentists and endodontists in this regard (P>0.05).

Table 1- Professional status of the participating specialists

Variable		Number (Percent)
Expertise	Endodontics	34 (50.7)
	Pediatric Dentist	33(49.3)
Sex	Man	29 (43.3)
	Woman	38 (56.7)
Duration of practice as a specialist	0 – 10 years	23 (34.3)
	11 – 20 years	25 (37.3)
	More than 20 years	19 (28.4)
Age	27 – 35 years	14 (20.9)
	36 – 45 years	25 (37.3)
	46 – 55 years	18 (26.9)
	56 and above.	10 (14.9)
	Public	3 (4.5)

Table 1- Professional status of the participating specialists					
Variable				**Number (Percent)**	
Workplace	Private			43 (64.2)	
	Public and Private			21 (31.3)	
The frequency of reading dental scientific journals	Every week.	23 (34.3%)	Endodontist	12 (35.3)	
			Pediatric Dentist	11 (33.3)	
	Every month	17 (25.4%)	Endodontist	7 (20.6)	
			Pediatric Dentist	10 (30.3)	
	Over the past year	23 (34.3%)	Endodontist	13 (38.2)	
			Pediatric Dentist	10 (30.3)	
	Never	4 (6%)	Endodontist	2 (5.9)	
			Pediatric Dentist	2 (6.1)	
Participation in training of regeneration treatments	Yes	40 (59.7%)	Endodontist	21 (61.8)	Chi2=0.12 P-value=0.72
			Pediatric Dentist	19 (57.6)	
	No	27 (40.3%)	Endodontist	13 (38.2)	
			Pediatric Dentist	14 (42.4)	

Part 2: Attitudes and viewpoints

Table 2 provides the separate views and opinions of experts. Specialists were surveyed regarding their perspectives on the timeframe for regeneration treatments to become commonly used in dentistry. The majority (55.6%) believed it would take between 0 and 10 years. In terms of their interest in participating in a dental regeneration treatment training course, 66.2% expressed their willingness.

When it came to the main obstacle for patients to accept dental regeneration treatment, 44.9% of respondents believed it was the high cost. On the other hand, 66.7% agreed that dental regenerative treatments were a better option than dental implants.

In terms of the most valuable outcomes of regenerative treatment, 51.5% emphasized the importance of root thickness increase.

Table 2- Opinions of endodontists and pediatric dentists regarding regenerative endodontics				
Question	**Variable**	**Number (percent)**	**Expertise**	**Number (percent)**
How long do you think it takes to commonly use regeneration treatments with stem cells in dentistry?	0 – 10 years	35 (55.6)	Endodontist	19 (61.3)
			Pediatric Dentist	16 (50)
	10 – 20 years	20 (31.7)	Endodontist	9 (29)
			Pediatric Dentist	11 (34.4)
	More than 20 years	8 (12.7)	Endodontist	3 (9.7)
			Pediatric Dentist	5 (15.6)
Would you like to take part in a training or continuing education course to use dental regeneration treatments?	Yes	43 (66.2)	Endodontist	21 (63.6)
			Pediatric Dentist	22 (68.8)
	No	10 (15.3)	Endodontist	6 (18.2)
			Pediatric Dentist	4 (12.4)
	not sure	12 (18.5)	Endodontist	6 (18.2)
			Pediatric Dentist	6 (18.8)
What do you think is the biggest obstacle to the acceptance of dental regeneration treatment?	High Cost	22 (44.9)	Endodontist	8 (38.1)
			Pediatric Dentist	14 (50)
	Fear of treatment.	12 (24.5)	Endodontist	4 (19)
			Pediatric Dentist	8 (28.6)
	Other Reasons	18 (36.7)	Endodontist	10 (47.6)
			Pediatric Dentist	8 (28.6)
Do you think regeneration treatment is a better option than dental implants؟	Yes	44 (66.7)	Endodontist	25 (75.8)
			Pediatric Dentist	19 (57.6)
	No	2 (3)	Endodontist	0

Table 2- Opinions of endodontists and pediatric dentists regarding regenerative endodontics				
Question	**Variable**	**Number (percent)**	**Expertise**	**Number (percent)**
			Pediatric Dentist	2 (6.1)
	not sure	20 (30.3)	Endodontist	8 (24.2)
			Pediatric Dentist	12 (36.3)
Which of the therapeutic consequences of regeneration do you think is most valuable?	Increase root length	28 (42.4)	Endodontist	16 (47.1)
			Pediatric Dentist	12 (37.5)
	Increase root thickness	34 (51.5)	Endodontist	18 (52.9)
			Pediatric Dentist	16 (50)
	Improvement of periapical lesion	14 (21.2)	Endodontist	8 (23.5)
			Pediatric Dentist	6 (18.8)
	Pulp Revitalization	41 (62.1)	Endodontist	22 (64.7)
			Pediatric Dentist	19 (59.4)

Part 3: Clinical practice

Table 3 provides the individual listing of specialists' clinical practice status. This part focused on their clinical utilization method of regeneration treatments. Among the participants, only 32.3% reported using these treatments. When evaluating the effectiveness of regeneration treatments, 58.5% considered them successful. In terms of the cases handled by specialists, 69.7% mentioned that less than 10% of the cases involved immature necrotic teeth. Specifically, 82.4% of endodontists and 56.3% of pediatric specialists fell into this category.

Regarding the material used for disinfecting the canal during regeneration treatment, most of them opted for calcium hydroxide, followed by Triple antibiotic paste, and double antibiotic paste. When it came to canal irrigation during regeneration treatment, they mostly used sodium hypochlorite, followed by normal saline, and EDTA. In terms of coronal sealing, most of them used MTA (Mineral Trioxide Aggregate), followed by CEM Cement, and ZOE (Zinc Oxide Eugenol). There was no significant statistical difference in the treatment materials used by endodontists and pediatric dentists (P>0.05).

57.6% of specialists considered pulp regeneration treatment as the ideal approach for necrotic immature teeth. 84.6% expressed their willingness to refer patients in situations where they were unable to perform a regeneration treatment. Only 6.1% never recommended this treatment.

Table 3- Clinical practices of endodontists and pediatric dentists regarding regenerative endodontics					
Question	**Variable**	**Number (percent)**	**Expertise**	**Number (percent)**	
Do you use regeneration treatments in your practice?	Yes	21 (32.3)	Endodontist	14 (42.4)	Chi2=3.13 P-value=0.07
			Pediatric Dentist	7 (21.9)	
	No	44 (67.7)	Endodontist	19 (57.6)	
			Pediatric Dentist	25 (78.1)	
What is your assessment of the results of dental regeneration treatments?	Successful	38 (58.5)	Endodontist	21 (63.6)	Chi2=2.20 P-value=0.33
			Pediatric Dentist	17 (53.1)	
	Failed	5 (7.7)	Endodontist	1 (3)	
			Pediatric Dentist	4 (12.5)	
	I don't know	22 (33.8)	Endodontist	11 (33.4)	
			Pediatric Dentist	11 (34.4)	
Is there an increase in the healing of periapical tissues when tissue engineering is used after non-surgical endodontic treatment?	Yes	36 (57.1)	Endodontist	19 (59.3)	Chi2=0.13 P-value=0.93
			Pediatric Dentist	17 (54.9)	
	No	2 (3.2)	Endodontist	1 (3.2)	
			Pediatric Dentist	1 (3.2)	
	I don't know	25 (39.7)	Endodontist	12 (37.5)	
			Pediatric Dentist	13 (41.9)	
What percentage of cases in your work	Less than 10 percent.	46 (69.7)	Endodontist	28 (82.3)	Chi2=8.59 P-value=0.03
			Pediatric Dentist	18 (56.3)	
	11% to 25%	7 (10.6)	Endodontist	4 (11.8)	

Table 3- Clinical practices of endodontists and pediatric dentists regarding regenerative endodontics

Question	Variable	Number (percent)	Expertise	Number (percent)	
involve immature necrotic teeth?			Pediatric Dentist	3 (9.3)	
	26 to 50 percent	0		0	
	More than 50 percent.	1 (1.5)	Endodontist	0	
			Pediatric Dentist	1 (3.1)	
	I don't do it at all.	12 (18.2)	Endodontist	2 (5.9)	
			Pediatric Dentist	10 (31.3)	
In what percentage of treatments have you included regeneration therapy for traumatized teeth?	Less than 10 percent.	42 (63.7)	Endodontist	25 (73.6)	Chi2=3.26 P-value=0.35
			Pediatric Dentist	17 (53.2)	
	11% to 25%	2 (%3)	Endodontist	1 (2.9)	
			Pediatric Dentist	1 (3.1)	
	26 to 50 percent	0		0	
	More than 50 percent.	2 (3)	Endodontist	1 (2.9)	
			Pediatric Dentist	1 (3.1)	
	I don't do it at all.	20 (30.3)	Endodontist	7 (20.6)	
			Pediatric Dentist	13 (40.6)	
What percentage of your treatments involve regeneration treatment for decayed teeth?	Less than 10 percent.	51 (89.4)	Endodontist	29 (90.6)	Chi2=1.31 P-value=0.51
			Pediatric Dentist	22 (88)	
	11% to 25%	5 (8.8)	Endodontist	3 (9.4)	
			Pediatric Dentist	2 (8)	
	26 to 50 percent	1 (1.8)	Endodontist	0	
			Pediatric Dentist	1 (4)	
	More than 50 percent.	0		0	
	I don't do it at all.	0		0	
hat materials do you use as edicament if you perform regeneration treatment?	Calcium hydroxide	28 (49.1)	Endodontist	17 (58.6)	Chi2=2.75 P-value=0.43
			Pediatric Dentist	11 (39.3)	
	Triple antibiotic paste	21 (36.8)	Endodontist	8 (27.6)	
			Pediatric Dentist	13 (46.4)	
	Double antibiotic paste	18 (31.6)	Endodontist	9 (31)	
			Pediatric Dentist	9 (32.1)	
	Other Materials	3 (5.3)	Endodontist	2 (6.9)	
			Pediatric Dentist	1 (3.6)	
What irrigation solution do you use in regeneration treatment?	Sodium hypochlorite	49 (80.3)	Endodontist	26 (78.8)	Chi2=2.61 P-value=0.45
			Pediatric Dentist	23 (82.1)	
	EDTA	21 (34.4)	Endodontist	13 (39.4)	
			Pediatric Dentist	8 (28.6)	
	Normal Saline	34 (55.7)	Endodontist	15 (45.5)	
			Pediatric Dentist	19 (67.9)	
	Other Materials	1 (1.6)	Endodontist	1 (3)	
			Pediatric Dentist	0	
What substance do you use for coronal seal in regeneration treatment?	MTA	43 (72.9)	Endodontist	23 (76.7)	Chi2=1.56 P-value=0.45
			Pediatric Dentist	20 (69)	
	CEM Cement	32 (54.2)	Endodontist	15 (50)	
			Pediatric Dentist	17 (58.6)	
	Zoe	12 (20.3)	Endodontist	4 (13.3)	
			Pediatric Dentist	8 (27.6)	
	Other Materials	0		0	
What do you think is the ideal treatment for immature teeth necrosis?	Calcium hydroxide Apexification	5 (8.5)	Endodontist	3 (10)	Chi2=0.11 P-value=0.99
			Pediatric Dentist	2 (6.9)	
	Application of calcium hydroxide then MTA plug and obturation of the rest of the canal	13 (22)	Endodontist	7 (23.3)	
			Pediatric Dentist	6 (20.7)	
	MTA plug and obturation of the rest of the	16 (27.1)	Endodontist	9 (30)	
			Pediatric Dentist	7 (24.1)	

Table 3- Clinical practices of endodontists and pediatric dentists regarding regenerative endodontics

Question	Variable	Number (percent)	Expertise	Number (percent)	
	channel				
	Pulp Regeneration Treatment	34 (57.6)	Endodontist	18 (60)	
			Pediatric Dentist	16 (55.2)	
If you can't perform a regeneration treatment, would you like to refer your patient?	Yes	55 (84.6)	Endodontist	26 (78.7)	
			Pediatric Dentist	29 (90.6)	
	No	4 (6.2)	Endodontist	2 (6.1)	Chi2=2.81 P-value=0.24
			Pediatric Dentist	2 (6.3)	
	not sure	6 (9.2)	Endodontist	5 (15.2)	
			Pediatric Dentist	1 (3.1)	
How much should dental regeneration treatment cost?	Equal to routine treatment	13 (21.7)	Endodontist	8 (27.6)	
			Pediatric Dentist	5 (16.2)	
	Over Current Treatment	34 (56.6)	Endodontist	17 (58.6)	
			Pediatric Dentist	17 (54.8)	Chi2=2.96 P-value=0.39
	Less than current treatment.	1 (1.7)	Endodontist	0	
			Pediatric Dentist	1 (3.2)	
	not sure	12 (20)	Endodontist	4 (13.8)	
			Pediatric Dentist	8 (25.8)	
What makes you recommend regeneration treatment to your patients?	If it is the most effective treatment option	51 (77.3)	Endodontist	27 (79.4)	
			Pediatric Dentist	24 (75)	
	If it is safe and reliable	21 (31.8)	Endodontist	8 (23.5)	
			Pediatric Dentist	13 (40.6)	
	If it is has the highest cost-benefit	0		0	Chi2=1.31 P-value=0.51
	I never recommend it.	4 (6.1)	Endodontist	2 (5.9)	
			Pediatric Dentist	2 (6.3)	

Discussion

This study aimed to explore the perspectives of endodontists and pediatric dentists regarding regeneration treatment. The majority (55.6%) of participants expected short-term results (<10 years) from stem cell treatments.

More than half (59.7%) were familiar with these treatments, and a significant majority (66.2%) expressed interest in training courses to enhance their knowledge. Rates for endodontists and pediatric dentistry specialists were nearly identical. A related study conducted by Utneja et al. [9] revealed that 50.6% of endodontic residents had received continuing education in this field. Additionally, 86.6% believed regenerative treatments should be integrated into dentistry, and 88% were willing to receive training.

Specialists had differing views on the main obstacle to patient acceptance: pediatric dentists mostly cited high costs, while endodontists pointed to the lengthy treatment process. Understanding these differing viewpoints can help develop strategies to address concerns of both patients and dental professionals. Addressing financial concerns and treatment process improvements could lead to wider acceptance of regeneration treatments. In Epelman's [8] and Naik's studies [10], over 50% of participants shared the belief that the high cost of stem cell therapy in dentistry is the primary obstacle to patient acceptance. This aligned with the opinion expressed by pediatric dentists in the present study.

Both groups of specialists agreed that the patient's anxiety about the treatment was the least likely reason for not accepting regeneration treatment. However, unlike the predictable outcomes associated with conventional root canal treatment, regenerative treatment of a necrotic tooth with an open apex may not yield consistent results.[11] Despite the clinician's efforts, adherence to treatment protocols, and the patient's financial investment, there is a potential for treatment failure, [12] which may be a factor contributing to the patient's reluctance of undergoing this treatment.

A majority of endodontists and pediatric dentists considered regenerative treatment to be a preferable option when compared to dental implants. This is primarily due to the fact that many of their patients, who are children, often experience loss of pulp vitality and subsequent necrosis in their developing anterior teeth as a result of traumatic injuries. Considering the young age, it is not practical to replace the affected tooth with a dental implant.[13] Only 3% of the

participants considered dental implants to be a better option than regenerative treatments. In Naik 's study [10], 85% of participants supported the concept of regeneration. However, in the study conducted by Utneja [9] and Epelman [8] only half of the participants disagreed with the use of dental implants.

Among both endodontists and pediatric dentists, pulp revitalization was the most highly regarded therapeutic outcome of regeneration treatments. Recently, there has been a growing recognition among clinicians about the importance of preserving pulp vitality, leading to an increased preference for regenerative treatments.[14] In terms of treatment outcomes, the most valuable results observed were the increase in root thickness and the increase in root length, respectively. In contrast, Manguno et al. [15] revealed that a majority of the residents held the belief that tissue engineering techniques have the potential to enhance periapical healing.

Approximately two-thirds of the surveyed dental specialists, comprising 57.6% of endodontists and 78.1% of pediatric dentists, indicated that they do not currently incorporate regeneration treatments into their practice. This finding is comparable to the outcomes found in the studies conducted by da Silva et al. [16] and Manguno et al. [15] in which a small portion of private practitioners and dental residents were found to be utilizing regenerative procedures. This could be due to a lack of expertise, the complexity of cases, and the unpredictable nature of treatment outcomes. Notably, a higher percentage of endodontists (42.4%) reported using regeneration treatments compared to pediatric dentists (21.9%), likely due to the similarities between regeneration and traditional root canal treatments on permanent teeth. As a result, it is expected that endodontists would perform regeneration treatments more frequently.

A majority of the participants (56.7%) believed that the cost of regenerative treatment should be higher than the routine treatment, with both endodontists and pediatric specialists sharing the same viewpoint. This can be attributed to the fact that regenerative treatment requires multiple sessions. This aligns with the findings of Manguno et al.'s [15] and Naik 's [10] studies.

Despite the limited utilization of regeneration treatments among clinicians, they often considered the outcomes of the treatment as successful, expressing a heightened probability of periapical tissue recovery through tissue engineering. Merely 7.7% of clinicians viewed the results as unsuccessful. This positive evaluation suggests that endodontists and pediatric dentists may be inclined to pursue additional training courses and increase their willingness to perform regeneration treatments.

Among pediatric dentists, a notable proportion of 31.3% reported not treating immature necrotic teeth at all, while only 5.9% of endodontists said the same. This discrepancy is likely because treating immature teeth is a crucial part of the endodontic residency curriculum and a significant portion of an endodontist's practice. Consequently, endodontists are expected to handle most of these treatments. Additionally, since permanent teeth are initially referred to endodontists for pulp treatments, it supports the likelihood that endodontists are primarily responsible for performing these treatments.

When it comes to performing regeneration treatment for immature necrotic traumatized teeth, 63.6% of respondents reported a success rate of less than 10%. Additionally, 30.3% of the participants indicated that they do not perform this treatment at all, which aligns with Naik's findings. [10] Interestingly, pediatric dentists were found to be twice as likely as endodontists to avoid performing this treatment altogether (40.6% vs. 20.6%). Treating traumatized teeth poses a challenge for clinicians, primarily due to the presence of unpredictable complications like root resorption. However, endodontists, with their in-depth understanding of these complications and effective management strategies, tend to handle these cases more frequently compared to professionals from other fields.

The study found that among the experts surveyed, 49.1% utilize calcium hydroxide as a medicament for disinfecting canals, followed by triple antibiotic paste at 36.8% and double antibiotic paste at 31.6%. Endodontists tended to use calcium hydroxide more frequently (58.6%) compared to pediatric dentists (39.3%). This difference may reflect variations in treatment approaches between the two specialties. Jamshidi et al. [17] in 2021, investigated the cytotoxicity and genotoxicity of triple antibiotic paste, double antibiotic paste, and calcium hydroxide on stem cells. The results indicated that none of the tested concentrations of calcium hydroxide had a significant effect on cells. However, both triple antibiotic paste and double antibiotic paste were found to have cytotoxic and genotoxic effects on stem cells.[17] In 2018, Arruda et al. [18] conducted a study to compare the antimicrobial effects of triple antibiotic solution and calcium hydroxide. The results demonstrated that the triple antibiotic solution significantly improved disinfection of the root canal. In this study, 36.8% of specialists chose triple antibiotic paste for canal disinfection in regeneration treatment.

In the present study, experts commonly used sodium hypochlorite to cleanse the canal during regeneration treatment. Sodium hypochlorite is highly effective against Gram-positive and Gram-negative bacteria and is recognized as the most potent antifungal agent among root canal irrigants. American Association of Endodontists (AAE) suggests using 1.5% sodium hypochlorite for the necrotic immature tooth.[19]

One-third of participants chose EDTA for regenerative treatment. EDTA at a concentration of 17% is known to release internal dentinal proteins. Following the use of EDTA, bleeding is typically induced to create a natural scaffold for stem cell delivery inside the canal.[20]

In this study, the most commonly used material for coronal sealing in regeneration treatment was MTA, followed by CEM Cement, and finally ZOE. MTA has been widely utilized as a barrier in many studies. This is mainly due to its

superior biocompatibility and inductive ability, which make it an ideal choice for promoting regeneration. MTA surpasses other materials in terms of its ability to create a tight seal against bacteria and support the regenerative process within the treated tooth.[21]

The study found that 57.6% of participants believed that regeneration treatment is the optimal approach for treating necrotic immature permanent teeth, surpassing MTA plug placement. Additionally, 84.6% expressed willingness to refer patients if they were unable to perform the treatment themselves. This suggests that dental specialists, despite facing challenges such as patient management or procedural difficulties, prefer to refer their patients for treatment rather than dismissing the option. Pediatric dentists had a higher referral rate (90.6%) compared to endodontists (78.8%).

Considering the findings, along with the advancements in regenerative treatments and the increasing focus on tooth preservation, it is recommended to propose modifications and revisions to the curriculum of specialized courses. Naik et al.[10] explored the perspectives of Saudi endodontic residents regarding regenerative treatment. A significant number of participants expressed the belief that regenerative endodontics should be incorporated into dental education, emphasizing the importance of updating dental curricula accordingly.

Additionally, these results can be utilized for planning training courses, retraining programs, and short-term professional courses. It is important to note that the study's scope was limited to specialists specifically from the city of Mashhad. While the sample size of 67 individuals was deemed appropriate, a larger sample size would have provided more dependable results. Therefore, generalizing the findings beyond this population should be done with caution.

Based on the findings and the variations in approaches and practices between the two specialized fields, it is advisable to establish specific guidelines for diagnosis and therapy in regenerative treatments. Additionally, offering comprehensive training programs that promote the exchange of interdisciplinary knowledge would be beneficial. These programs would not only enhance professionals' skills but also ensure that they remain up to date with the latest advancements in regenerative treatments even after completing their post-graduate courses.

Conclusion

Within the limitations mentioned, it could be concluded that only one third of specialists perform regenerative treatment Among those who offer this treatment, endodontists appear to account for a higher percentage compared to pediatric dentists. Additionally, more than half of the experts expressed an interest in receiving training for regeneration therapy.

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