

Regenerative Endodontics in Pakistan: A Survey of Dental Specialists' Knowledge, Attitudes, and Practices

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ABSTRACT

Objectives: This study aimed to evaluate the awareness, attitudes, and practices regarding regenerative endodontic procedures (REPs) among dental clinicians in Pakistan. The focus was on understanding clinicians' knowledge of REPs, their perceptions of its efficacy compared to traditional methods, and their practical approaches to managing immature necrotic permanent teeth.

Materials and Methods: This descriptive cross-sectional survey involved 178 dental clinicians from various specialties, including endodontics, Pediatric dentistry, Orthodontics, Prosthodontics, Periodontics, Oral Surgeons and general practice. Data were collected using a structured questionnaire covering demographics, knowledge, attitudes, and clinical practices related to REPs. Statistical analysis was performed to identify trends and significant associations.

Results: The survey revealed that 66.3% of participants believed there is sufficient evidence supporting REPs, and 83.1% considered REPs superior to apexification. Most clinicians (73.6%) preferred REPs over Osseo-integrated implants for managing immature necrotic permanent teeth, though 58.4% would refer these cases to endodontists. For disinfection, 41% favoured a combination of antibiotics and calcium hydroxide, while 48.3% relied on clinical guidelines from the American Association of Endodontists (AAE) and published literature for their protocols. Despite high levels of knowledge and positive attitudes towards REPs, practical gaps were identified, indicating a need for further training and standardized clinical guidelines.

Conclusion: Dental clinicians in Pakistan exhibit good knowledge and positive attitudes towards REPs. However, practical implementation shows variability, underscoring the need for enhanced education and standardized protocols to ensure optimal clinical outcomes in regenerative endodontics.

Keywords: Apexification, Dental Education, Dental Pulp Necrosis, Endodontic Procedures, Regenerative Endodontics

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INTRODUCTION

Managing young permanent teeth affected by pulp necrosis is a considerable difficulty for dental practitioners.¹ Immature teeth with pulp necrosis due to decay or trauma often exhibit incomplete root formation, thin dentinal walls, and an open apex. These anatomical challenges hinder the effectiveness of conventional endodontic cleaning, shaping, and obturation techniques.²

The management of necrotic immature permanent teeth involves two main approaches: apexogenesis and apexification. Apexogenesis preserves pulp viability to support root development, while apexification uses materials to create a barrier for root-end closure.³ Despite its widespread use, apexification has limitations. Repeated intracanal medication, especially with calcium hydroxide, increases reinfection risk, and extensive instrumentation can weaken canal walls.⁴

A growing body of research investigating the regenerative potential of the dental pulp suggests the possibility of inducing the biological substitution of cells constituting the dentin-pulp complex. This approach could lead to the regeneration of pulp tissues, the stimulation of continued root development, and potentially, the revitalization of the entire tooth structure.⁵ Regenerative endodontic procedures are based on three core principles of tissue engineering: the use of mesenchymal stem cells (MSCs), scaffold materials, and growth factors.⁶ Research interest in tissue engineering, particularly in its application to pulp regeneration, has noticeably increased in recent years, which is a significant accomplishment for the field of dentistry.⁷ Consequently, the American Association of Endodontists (AAE) recommends that young permanent teeth with dead pulp should get regenerative endodontic treatment.⁸

It is possible to conclude that the current application of regenerative endodontics is simply a preview of the developments and applications that are anticipated to take place in the next ten years. On the other hand, these cutting-edge treatments must enter clinical practice after being developed in laboratory settings. Because of this, there is a need for improved research quality as well as collaboration efforts across various physicians and researchers.⁸

Regenerative endodontics represents a fundamental change from conventional endodontic procedures,

with a specific emphasis on the restoration of pulp tissues such as dentin, blood vessels, and nerve tissues through regeneration.⁹ The unique healthcare, socio-economic, and educational landscape of Pakistan provides an opportunity to explore regional differences in the adoption of regenerative endodontic protocols. Many dental practitioners rely on traditional therapies due to limited exposure, insufficient training, or lack of confidence in adopting regenerative techniques. By investigating practitioners' perspectives, this study aims to identify barriers such as inadequate education, limited resources, and unclear protocols, as well as factors that facilitate adoption. Examining clinical practices across specialties will offer insights into the practical application of regenerative techniques, highlighting areas for improvement. This research seeks to bridge these gaps, enhance current knowledge, and support the development of targeted educational programs and treatment strategies to advance clinical practice. The objective of this study was to determine the levels of awareness, attitudes, and practices regarding regenerative endodontic procedures (REPs) among clinicians representing different dental specialties in Pakistan.

MATERIALS AND METHOD

A descriptive cross-sectional questionnaire-based survey was conducted among Pedodontists, Endodontists, General Practitioners, orthodontists, prosthodontists and oral surgeons across Pakistan. After obtaining ethical approval (#34-ERB /024) from the institutional ethical board of Saidu College of Dentistry, Saidu Shareef Swat. A convenience sampling technique was used for selecting the participants. The sample size for this study was determined using the OpenEpi software, based on the anticipated proportion of 34.6%² of participants who responded to their opinions and beliefs about regenerative endodontic procedures. To achieve a confidence level of 95% with an absolute precision of 7%, the calculated sample size required was 178 participants. The questionnaires were distributed via a web-based survey using Google Forms and were sent through electronic media including WhatsApp, Facebook and Gmail. Before completing the online questionnaire, participants were required to fill out a consent form. The survey proceeded only for those who provided their consent.

The questionnaire utilized in this study was adopted from the research conducted by Jamal et al.², following

explicit consent obtained through email correspondence. The questionnaire consisted of three sections: Part A, comprised of four inquiries focused on sociodemographic details and the professional status of dentists; Part B (Q5–10), addressing queries regarding dentists’ viewpoints, convictions, and stances concerning the utilization of Regenerative Endodontic Procedures (REPs); and Part C (Q11–17), concentrating on clinical protocols, to be completed exclusively by respondents indicating their personal engagement in performing REPs (Q10). Data was analyzed using IBM SPSS version 27. Frequencies and percentages were computed for summarizing categorical variables.

RESULTS

A total of 185 participants were approached and out of them 178 responded to the survey. Most of them were endodontists (34.8%), had work experience of 0-5 years (64%), worked in an academic institution (42.7%) and did not attend a course on stem cells and regeneration (89.9%). (Table 1)

Table 1: Profile of Participants.

Questions	Characteristics	n (%)
What’s your specialty?	Endodontist	62 (34.8)
	Periodontist	8 (4.5)
	General Physician	35 (19.7)
	Prosthodontist	32 (18.0)
	Orthodontist	20 (11.2)
	Oral Surgeon	21 (11.8)
How many years in practice since graduation?	0-5 years	114 (64.0)
	5-10 years	38 (21.3)
	10-15 years	24 (13.5)
	15-20 years	1 (0.6)
	>20 years	1 (0.6)
Where do you practice?	Academic institution	76 (42.7)
	Government based practice	49 (27.5)
	Part time educator with private practice	43 (24.2)
	Private practice	10 (5.6)
Have you attended a course on stem cells and regeneration?	Yes	18 (10.1)
	No	160 (89.9)

About one-third of participants believed that there

is enough evidence to support REPs (66.3%) and evidence that functional pulp tissue can be regenerated with REPs (66.9%). More than three-fourths had a view that REPs are a better treatment option than apexification (83.1%). Nearly one third thought that tooth can be regenerated in the laboratory during 1-10 years (35.1%). Most of the participants had the perception that implanting a regenerated tooth is a better option compared to the use of Osseo-integrated dental implants (76.4%). The majority said they refer the patient to an endodontist if there would be a need to perform REPs (58.1%) (Table 2).

Table 2: Opinions and Beliefs Toward REPs

Questions	Characteristics	n (%)
Do you believe there is enough evidence to support REPs?	Yes	118 (66.3)
	No	60 (33.7)
Do you believe there is enough evidence that a functional pulp tissue can be regenerated with REPs	Yes	119 (66.9)
	No	59 (33.1)
Do you believe that REP is a better treatment option compared with apexification?	Yes	148 (83.1)
	No	30 (16.9)
When do you believe an entire tooth can be regenerated in the laboratory?	0-10 years	63 (35.4)
	10-20 years	28 (15.7)
	20-30 years	39 (21.9)
	>30	47 (24.4)
	It will never happen	1 (0.6)
	Do you believe that implanting a regenerated tooth is a better option compared to the use? Of Osseo-integrated dental implant?	Yes
	No	42 (23.6)
When indicated and possible, are you willing to perform REPs or you prefer to refer to endodontist?	Perform REPs myself	74 (41.6)
	Refer to an endodontist	104 (58.4)

More than half of them said the case of tooth with necrotic pulp and immature apex would be most comfortable case for doing REPs (54.5%) and will perform it in two visits (61.8%). Majority were using mixture of antibiotics and calcium hydroxide to achieve disinfection of the root

canal system (53.4%). Ratio of 1:1:1 of ciprofloxacin: metronidazole: minocycline was mostly preferred by participants (63.5%). Around of participants said that they would deliver the stem cells in the root canal system using initial bleeding from the peripheral area (48.9%). Nearly half of participants were relaying on The AAE’s clinical consideration for REPs (48.9%) and published literature (48.3%) for developing the protocol for REPs (Table 3).

Table 3: Distribution of Clinical Practice Related to REPs

Questions	Characteristics	n (%)
Which cases would you be comfortable doing REPs on?	Tooth with necrotic pulp and an immature apex	97 (54.5)
	Tooth with necrotic pulp and mature apex	31 (17.4)
	Both of the above	50 (28.1)
How many visits would you require to perform REPs?	1 visit	12 (6.7)
	2 visits or more	110 (61.8)
	Can be done over 1 visit or continued for more visits	56 (31.5)
Which of the following would you use to achieve disinfection of the root canal system?	Mixture of antibiotics	54 (30.3)
	Calcium hydroxide	29 (16.3)
	Both of above	95 (53.4)
Which ratio of the antibiotic mixture would you prefer?	1:1:1 of ciprofloxacin: metronidazole: minocycline	113 (63.5)
	1:2:1 of ciprofloxacin: metronidazole: minocycline	43 (24.2)
	1:2:2 of ciprofloxacin: metronidazole: minocycline	6 (3.4)
	2:2:1 of ciprofloxacin: metronidazole: minocycline	16 (9.0)

Which concentration of each antibiotic would you prefer in the antibiotic mixture? (mg/ml)	0.1	46 (25.8)
	1	124 (69.7)
	10	8 (4.5)
How would you deliver the stem cells in the root canal system?	Orthograde delivery of the stem cells through a syringe	33 (18.5)
	Initiating bleeding from the periapical area	87 (48.9)
	Both of the above	58 (32.6)
The sources that you use to develop your protocol is based on: (multiple response)	The AAE’s clinical consideration for REPs	87 (48.9)
	Published literature	86 (48.3)
	Continuous education course	56 (31.5)
	Colleagues unsure	18 (10.1)

DISCUSSION

An encouraging finding of our study is that, although most of the participants had work experience ranging from zero to five years, only few of them attended a course on stem cells and regeneration, indicating the need to upgrade their knowledge and skill set and learning new endodontic techniques. Oral surgeons were ranked second in terms of attending these courses, after endodontists.

The majority of participants believed that there was sufficient data to support REPs and the regeneration of functional pulp tissue using REPs Furthermore, a greater percentage of dentists (83.1%) concurred that restorative enamel grafting (REP) is a superior therapeutic choice than apexification. A 2019 Indian study revealed a lack of understanding of regenerative endodontics. Other surveys, however, indicated that respondents knew more about using REP rather than apexification.⁸ According to Saudi Arabian research, 85% of dentists claimed they advise patients to get REPs.² The higher preference in the most recent studies may be explained by the fact that newer research on REPs indicates that REPs outperform apexification in terms of enhanced root thickness and length.¹⁰

Dental implants are used to replace lost teeth, endodontic therapy for pulp necrosis, and cavity fillings are all examples of current dental repair procedures that involve synthetic materials. By using biologically based

treatment procedures for critical tissue regeneration, the fields of Tissue Engineering and Regenerative Medicine and Dentistry (TERMD) on the other hand, offer the possibility of regenerating living tissues.¹¹ Based on our growing understanding of the mechanisms governing tooth growth, the natural regulation of tooth morphology in the human body, and the research of signal pathways involved in tooth regeneration, tooth regeneration engineering has garnered a lot of attention recently. In 2012, there were approximately 473 publications on tooth regeneration, and research in this field has continued to increase over time.^{12,13} The results of our survey highlight the significance of this ongoing progress in dental tissue bioengineering, since the majority of participants believed that complete teeth would one day be regenerated.

Given the abundance of research that supports regenerative endodontics procedures, it is not unexpected that a significant fraction of our study participants (76.4%) favoured REP over osseointegrated titanium implants.^{14,15} The results align with other comparable surveys conducted in the United States.² Only 57.6% of dentists, however, preferred to choose regenerative dentistry over implant or prosthesis insertion, with 35.7% remaining uncertain. Despite the success of dental implants, we believe that the incidence of pain and inflammation following dental implants should be minimized to provide optimal treatment alternatives.¹⁶

The majority of our participants said that they refer their patients to endodontists to undergo REPs (58.4%). This might be possible that REPs fall in the domain of endodontics. However, 41.6% of our participants were willing to perform it themselves. This depicts a positive response that dental practitioner was enthusiastic to learn and apply the technique in their clinical settings. A significant portion of endodontists also suggested that regenerative endodontic procedures should be utilized in dentistry.¹⁷ According to an Indian study, dental residents believe that stem cell and regenerative dental treatment is the most successful (43%) and safest method (48.7%), thus they would prescribe it to patients.¹⁸

In this study, approximately half of the participants reported feeling at ease conducting REPs on teeth that had an immature apex and necrotic pulp (54.5%). However, in the study by Jamal M et al², this percentage was greater at 72%. Predominantly, REP success is

documented in situations with necrotic immature teeth.^{19,20} The regenerative endodontic procedure (REP) can promote the continuous development of root width and length in immature teeth, requiring an appropriate coronal seal, a suitable matrix for tissue ingrowth, and effective infection control.²¹

The efficient removal of germs and their byproducts from the root canal system is the main factor determining the outcome of endodontic treatment.²² The American Association of Endodontics (AAE) and the European Society of Endodontology (ESE) presently advise using Ca(OH)₂ paste or antibiotic mixtures.^{23,24} The majority of our participants (53.4%) chose to use a combination of antibiotics and calcium hydroxide. Findings of other studies reported that almost the same proportion of participants were using a mixture of antibiotic paste (40.4%) and both calcium hydroxide and mixture of antibiotic paste (39.4%).^{2,17,25} Those who adhered to the ESE guidelines exhibited a preference for Ca(OH)₂ in comparison to those who followed alternative rules. The risks of antibiotic resistance, sensitization, cytotoxicity, obtaining the recommended antibiotic mixture, removal from the root canal difficulty, and coronal discoloration are just a few of the drawbacks of TAP/double antibiotic paste (DAP) that are mitigated by the more affordable Ca(OH)₂.⁵

The toxic impact on apical papilla stem cells (SCAP) is positively correlated with TAP concentration. While antibacterial activity declines at concentrations <1 mg/mL, concentrations of 1 mg/mL do not influence SCAP survival and no toxic effects are observed at lower doses (0.01–0.1 mg/mL). The best concentration of the antibiotic combination to combat endodontic bacteria with the least amount of harm to stem cells has not yet been established. Generally speaking, the AAE advises using TAP or DAP at low concentrations (0.1–1.0 mg/mL).²³ The majority of study participants (95.5%) chose concentrations between 0.1 and 1 mg/mL, indicating that they followed the current guidelines.

All published studies by RET propose the usage of a scaffold.^{19, 20} Approximately 50% of the participants thought that the most effective way to introduce stem cells into the root canal system was to start bleeding from the periapical area. However, the need for blood collection from the patient using other techniques like PRF, CGF,

and PRP, in addition to the additional expenditures and the need for the right tools and training to prepare the scaffold in an aseptic environment, maybe the factors limiting their adoption.

This survey reveals that nearly half of the participants were relied on The AAE's clinical consideration for REPs (48.9%) and published literature (48.3%) for developing the protocol for REPs whereas some were also depended on continuous education courses and one-tenth were unsure about it. Previous surveys also reported published literature as a source on which participants were depending for REPs protocol development.^{2,19} This reveals a lack of standard treatment protocol. However, the reliance of half of the participants on AAEs indicates that dentists are not uniformly using a single protocol. Thus, there is a need to emphasize the use of a standardized guidelines and protocols should be to maximize the possibility of favorable clinical outcomes for REPs.

The present survey includes both endodontists and other dental practitioners so to assess knowledge among other dental practitioners a larger survey should be conducted to generalize the findings of this study.

CONCLUSION

The present survey revealed good knowledge and attitude of study participants towards REPs However, there are some aspects of practice which needs serious attention which can be addressed with ongoing training and education.

DISCLAIMER

None.

CONFLICT OF INTEREST

None to declare.

ETHICAL STATEMENT

Ethical approval acquired from the Institutional ethical review board of Saidu Medical College, Saidu Shareef Swat. (#34-ERB/024)

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AUTHORS CONTRIBUTION

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