

Knowledge, Attitude, and Perception Among Endodontists Toward Regenerative Endodontics: A Cross-sectional Survey of Four Indian Universities

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ABSTRACT

Background: Regenerative endodontics is a rapidly developing field in dentistry. However, the regenerative endodontic procedures are not familiar to many clinicians in India. **Aim:** This survey aimed at assessing the level of knowledge, attitude, and perception (KAP) among endodontists toward regenerative endodontics. **Materials and Methods:** A cross-sectional survey was conducted in the year 2019 to collect data. A questionnaire to collect data on KAP toward regenerative endodontics was administered to 49 faculty and 69 postgraduate students of endodontics from four universities. The Chi-Square test and logistic regression were applied to study the association between KAP and demographic variables. Spearman's rho was computed to study the correlation between KAP scale scores of the participants. The data were analyzed by using Statistical Package for the Social Sciences software program (SPSS), version 15.0 (South Asia, Bangalore). **Results:** The survey yielded an overall response rate of 81%. Less than 50% of the participants had sound knowledge, 65% had a positive attitude, and only 21% had a positive perception about Regenerative Endodontic Procedures (REPs). Most of the participants (86.5%) were of the opinion that regenerative therapies should be a part of dentistry. Majority of the participants (89.6%) were inclined to receive training in REPs. About 80% of the participants felt that the higher cost of treatment is a significant hurdle for patients to accept REPs. Less than half the participants (41.7%) were using REPs in their clinical practice, such as the use of membranes, scaffolds, and revascularization. **Conclusion:** Endodontists have a positive attitude toward the use of regenerative therapies. However, there is a deficiency of training in REPs in dental colleges.

KEYWORDS: Dental pulp necrosis, regenerative endodontics, revascularization, stem cells, tissue engineering

INTRODUCTION

The use of a variety of biologically inspired therapeutic procedures has made dentistry a trailblazer of regenerative medicine.^[1] Advancing research in the area of dental pulp regeneration emphasizes the range of opportunities available for a clinician to incorporate newer and alternative techniques in their daily dental practice.^[2]

A meteoric advancement toward such clinical translation demands more frequent practice and use of regenerative endodontics for achieving various therapeutic goals.

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A long-term goal of endodontics has been the regeneration of the pulp–dentin complex. Since the inception of regenerative endodontics, application of the concept of tissue engineering to various treatment modalities of endodontics has developed widespread interest. The creation and delivery of new replacement tissues to manage damaged dentin and root structures, as well as cells of the pulp–dentin complex, is referred to as regenerative endodontics.^[3] Revascularization via blood clotting, stem cell therapy using postnatal stem cells of dental origin, implantation of replacement pulp tissue, scaffold implantation, three-dimensional cell printing, injectable scaffold, and gene therapy are potential technologies for regenerative endodontics.

It can be speculated that the current uses of regenerative endodontics are but only a glimpse at the advances and application of these procedures in the next decade. However, these novel therapies must be adapted from the labs to clinics. This requires higher quality research combined with collaboration between the researchers and clinicians.^[4]

The field of regenerative endodontics remains an uncharted territory in clinical practice for a majority of endodontic practitioners in India. Though regenerative procedures are slowly gaining acceptance in colleges in India, information regarding the views of endodontists toward regenerative procedures is scarce but essential for the widespread practice of these procedures.

Epelman *et al.* surveyed the opinions of endodontists who were members of the college of diplomats of the American Board of Endodontists toward regenerative endodontics.^[5] Manguno *et al.* also conducted a similar survey among U.S. dentists.^[6] The last and only survey conducted in India was by Utneja *et al.*^[7]

The guidelines laid down by the Indian Council of Medical Research for using stem cells in research have not emphasized the ethics of using stem cell therapies and regenerative dental procedures. The opinions of the faculty and residents of various dental colleges may be beneficial in modifying and updating the recommendations for making regenerative endodontic procedures safer. This will also help in determining whether any modifications or more emphasis on REPs is required in the current postgraduate curriculum. Therefore, the aim of this study was to assess the level of KAP among endodontists toward regenerative endodontics.

MATERIALS AND METHODS

The Institutional Ethics Committee approved this study (AJEC/REV/94/2018).

STUDY DESIGN AND DATA COLLECTION TOOL

Data for the study were collected through a cross-sectional survey conducted in the year 2019 (January to April). A questionnaire assessing the KAP was the instrument for data collection. A tool developed originally by Epelmen *et al.* and later modified by Utneja *et al.* for a similar study on Indian endodontic residents was used in the current study.^[5,7] We excluded two items, one that we felt was redundant and another asking for the location of the respondents from this tool as the location in our study is restricted to coastal Karnataka. Expert opinion regarding the content validity of this tool was taken by circulating the questionnaire to three endodontic faculties at the level of associate professor/ professor. All the three experts agreed on the suitability and adequacy of the items in the tool for carrying out the current study. The experts agreed that the tool includes items representing the profile of the participants [Table 1], facts (seven items), general attitude (five items), perceptions toward REPs (five items), and knowledge (five items) are specific to clinical applications of these procedures [Table 2]. As per the suggestion of the experts, KAP items were given a score of 1 if the response was correct / indicates positive attitude or perception, else they scored zero. The correct response /positive attitude or perception is indicated by a “*” in Table 2. The sum of the scores of KAP items varied between “0” and “5.” The sum of the five item scores was categorized to present the level of KAP of the respondents [Table 3]. The questionnaire was pretested for ambiguity and clarity, circulating it to six endodontic first-year postgraduate students. The feedback from them was collected through oral discussion as well as in written form. All the six were satisfied with the simplicity of the language used.

Table 1: Profile of endodontists who participated in the study

	<i>n</i>	Percentage
Characteristic	96	100
Position		
Faculty	36	37.5
Postgraduates	60	62.5
Age		
≤30	61	63.5
>30	35	36.5
Gender		
Male	40	41.7
Female	56	58.3
Practice hours/clinics per week		
≤20 h	32	33.3
>20 h	64	66.7

Table 2: KAP of endodontic faculty and postgraduates toward regenerative endodontics

	<i>n</i> = 96 Percentage	
Attitude and perceptions toward REPs		
(A) Have you ever received continued education in stem cells and/ or regenerative dental treatments?		
Yes*	43	44.8
No	53	55.2
(A) Should regenerative therapy be incorporated into dentistry?		
Yes*	83	86.5
No	3	3.1
May be	10	10.4
Have you or any of your relatives used umbilical cord or other types of stem cell banking?		
Yes	18	18.8
No	66	68.8
Unsure	12	12.5
(K) Do you think that dental stem cell banking will be useful to be able to regenerate dental tissues?		
Yes*	65	67.7
No	2	2.1
Unsure	29	30.2
(P) How many years do you think it will take for some regenerative stem cell therapies to be used in dentistry?		
0–10 years*	50	52.1
11–20 years	31	32.3
More than 20 years	13	13.5
Never	2	2.1
(A) Would you be willing to attend a training course and/ or continuing education courses to apply regenerative dental treatments?		
Yes*	86	89.6
No	4	4.2
Unsure	6	6.3
What do you think would be the biggest obstacle to a patient accepting regenerative dental treatment?		
Higher cost	77	80.2
Fear of stem cells	5	5.2
Other reasons	14	14.6
(A) Would you be willing to save teeth and dental tissue for future regenerative dental treatment?		
Yes*	84	87.5
No	2	2.1
Unsure	10	10.4
(P) Do you think that regenerative dental treatment will be a better treatment option than tooth implant placement?		
Yes*	61	63.5
No	9	9.4
Unsure	26	27.1
(K) Do you think stem cells and regenerative treatments should be tested on animals before clinical testing?		
Yes*	69	71.9
No	10	10.4
Unsure	17	17.7
(P) Do you believe that dental professional associations should regulate the use of stem cell and regenerative dentistry?		
Yes*	76	79.2
No	6	6.3
Unsure	14	14.6
Clinical application of REPs		
Do you use any type of regenerative procedures in your practice, such as the use of membranes, scaffolds, or revascularization?		
Yes	40	41.7
No	56	58.3

Table 2: Continued

(P) What is your assessment of regenerative dental treatment outcomes?		
Successful*	38	39.6
Unsuccessful	2	2.1
Don't know	56	58.3
(K) After nonsurgical root canal treatment, would the healing of periapical tissues be enhanced by tissue engineering?		
Yes*	52	54.2
No	7	7.3
Don't know	37	38.5
(K) Which of the following regenerative endodontic treatments is the most valuable?		
Healing of periradicular bone	1	1.0
Continued root development in immature teeth	9	9.4
Pulp tissue revitalization within a root canal	27	28.1
Tooth reimplantation	4	4.2
All of the above*	55	57.3
What percentage of cases in your practice involves necrotic immature teeth?		
Less than 10%	62	64.6
11–25%	27	28.1
26–50%	3	3.1
More than 50%	4	4.2
What percentage of cases in your practice involves avulsed or traumatized teeth?		
Less than 10%	60	62.5
11–25%	30	31.3
26–50%	6	6.3
More than 50%	0	0
What percentage of cases in your practice involves periradicular lesions?		
Less than 10%	9	9.4
11–25%	26	27.1
26–50%	46	47.9
More than 50%	15	15.6
(P) What do you consider to be the optimal treatment for necrotic immature teeth?		
Calcium hydroxide apexification	3	3.1
Calcium hydroxide application followed by MTA apical plug and backfilling with obturation material	29	30.2
MTA apical plug and backfill with obturation material	48	50.0
Tribiotic paste and pulpal regeneration*	16	16.7
(A) Would you be willing to collect dental tissue for stem cell banks?		
Yes*	63	65.6
No	13	13.5
Unsure	20	20.8
(K) What should the cost for regenerative dentistry be?		
Equal to current treatment	22	22.9
More than current treatment*	63	65.6
Less than current treatment	1	1.0
Unsure	10	10.4
What would make you most likely to recommend stem cell and regenerative dental treatments to your patients?		
If it is the most effective treatment option	53	55.2
If it is safe and reliable	32	33.3
If it is the most cost-effective option	6	6.3
I would never recommend it	5	5.2

“*” indicates correct response/positive attitude or perception

K = knowledge, A = attitude, P = perception

STUDY POPULATION

Faculty and postgraduate students of endodontics who were in the second and final year of their course

at six dental colleges of the four universities situated in Coastal Karnataka were the target population in this study. The first-year postgraduates were excluded

Table 3: Respondents' KAP about regenerative endodontics

	Faculty	Postgraduates	Total
Category and knowledge score	n (%)	n (%)	n (%)
Good (4–5)	13 (36.1)	31 (51.7)	44 (45.9)
Fair (3)	8 (22.2)	14 (23.3)	22 (22.9)
Poor (0–2)	15 (41.7)	15 (25.0)	30 (31.2)
Total	36 (100)	60 (100)	96 (100)
Category and attitude score			
Positive (4–5)	19 (52.8)	43 (71.7)	62 (64.6)
Neutral (3)	12 (33.3)	10 (16.7)	22 (22.9)
Negative (0–2)	5 (13.9)	7 (11.7)	12 (12.5)
Total	36 (100)	60 (100)	96 (100)
Category and perception score			
Positive (4–5)	6 (16.7)	14 (23.3)	20 (20.8)
Neutral (3)	7 (19.4)	21 (35.0)	28 (29.2)
Negative (0–2)	23 (63.9)	25 (41.7)	48 (50.0)
Total	36 (100)	60 (100)	96 (100)

from the study since the initial part of their curriculum mainly deals with preclinical work and their knowledge of REPs would be very limited. There were a total of 56 faculties and 72 postgraduate (second and third year) students in these institutions.

SAMPLE SIZE AND DATA COLLECTION

Assuming that 50% of the subjects in the target population have knowledge of regenerative endodontics for a population size of 128 (56 faculty and 72 postgraduate students), the study would require a sample size of 97 for estimating the expected proportion with 5% absolute precision and 95% confidence. As the population size was only 128, we decided to carry out the survey through complete enumeration.

Permission for distributing the questionnaires was obtained from the Dean/ Principal of the institutions. The questionnaires were then distributed in person to 49 faculty and 69 postgraduate students of endodontics (total 118) who were present on the day of our visit to the institutions. The questionnaires were collected back after one week. The study covered about 88% of the total faculty and 96% of the postgraduates.

ETHICAL CONSIDERATION

The participation was voluntary, and anonymity was maintained. Respondents were assured of confidentiality of the data. The questionnaires were administered with oral consent of the participants.

STATISTICAL ANALYSIS

The data were summarized by computing frequency and percentage. Spearman's rho was computed to study the correlation between KAP. The χ^2 test and logistic regression were applied to study the association between KAP and demographic variables. The statistical package SPSS v.15 (South Asia, Bangalore) was used to summarize the data.

RESULTS

Out of 118 questionnaires circulated, 96 participants responded to the survey, yielding an overall response rate of 81%. Among the 96 participants who responded, 36 were faculty and 60 were postgraduate students. The response rate among the faculty members was 73% and, among postgraduate students, it was 87%.

Table 1 shows the summary of demographic variables of the respondents; Table 2 shows the descriptive summary of KAP of the participants; and Table 3 shows the KAP level of the participants. About 52% of the postgraduates and 35% of the faculty had sound knowledge of regenerative endodontics. More than 70% of the postgraduates and 53% of the faculty had a positive attitude. Only 23% of the postgraduates and 17% of the faculty had a positive perception toward regenerative endodontics. Overall, less than 50% of the respondents had sound knowledge, 64.6% had a positive attitude, and only 20.8% had a positive perception about regenerative endodontics.

Table 4 shows the correlation between KAP scores. There was a moderate correlation between knowledge and attitude as well as between attitude and perception. A low correlation was observed between knowledge and perception. The correlation between KAP was both positive and significant ($P < 0.001$).

The univariate analysis presented in Table 5 shows that a significantly higher percentage of females had a positive attitude ($P = 0.003$) and positive perception ($P = 0.007$). The study indicated a significantly higher percentage of the younger age group with a positive attitude ($P = 0.41$).

Table 6 shows the result of multiple logistic regression. The analysis indicated that of all the demographic

variables, only gender is significantly associated with positive attitude ($P = 0.006$) and positive perception ($P = 0.013$) [Table 6]. Females had 3.56 times more odds of having a positive attitude and 5.29 times more odds of having positive perception.

DISCUSSION

The identification of dental pulp stem cells in the deciduous and permanent teeth has raised an interesting possibility of using them for regenerative procedures.^[8]

Only one study among the endodontic residents of India that assesses the KAP of REPs among dentists is available in the scientific literature.^[9] The opinions of the endodontic residents and faculty are required to help develop ethical recommendations and to evaluate the potential acceptance of regenerative endodontic procedures among endodontic practitioners. The current study provides a valuable insight into the ethical opinions and judgments of the endodontic residents and faculty while providing regenerative endodontic treatments.

Since the groundbreaking case reports by Banchs and Trope, and Iwaya *et al.*, many other case reports have shown the healing of periapical lesions, radiolucencies, and continuation of root development by using regenerative procedures on immature non-vital teeth.^[10-12] In their case series, Bakhtiar *et al.* reported the resolution of periapical lesions, further

root developments, and apical closures in all cases when using platelet-rich fibrin as a scaffold, in immature teeth with necrotic pulp.^[9]

Sufficient knowledge, interest, and research among the endodontists comprise a prime requisite for this approach to reach clinical relevance. This survey was, thus, conducted to gather data on the degree of KAP of the clinical status of stem cell therapies and REPs among the endodontic residents and faculty.

An enthusiastic response was obtained from the residents and faculty of the various dental colleges, wherein more than 80% expressed that regenerative therapies should be a part of daily dentistry. More than half of the participants were optimistic about its use in dentistry in the next decade. An increase in the number of case reports displaying the success of regenerative endodontic therapies as well as the recent surge in webinars and public discussions on this topic could be the reason for this positive response and optimism.

The majority of the participants (89.6%) felt a need to attend further training in REPs. This reflects their underlying lack of knowledge and their positive attitudes toward regenerative endodontic procedures.

Most participants were ready to save teeth and dental tissues for future REPs and felt that it would be a better alternative to the placement of implants. The majority

Table 4: Correlation between KAP scores*

		Attitude	Perception
Knowledge	Correlation coefficient	.527	.352
	P-value	<.001	<.001
Attitude	Correlation coefficient	-	.432
	P-value	-	<.001

*Spearman’s rho ($n = 96$)

Table 5: Chi-square test showing association between KAP and demographic variables

	N	Good knowledge		Positive attitude		Positive perception	
		Yes, n (%)	χ^2 (P-Value)	Yes, n (%)	χ^2 (P-value)	Yes, n (%)	χ^2 (P-value)
Sex							
Male	40	15 (37.5)	1.92 (0.166)	19 (47.5)	8.75 (0.003)	3 (7.5)	7.39 (0.007)
Female	56	29 (51.8)		43 (76.8)		17 (30.4)	
Position							
Faculty	36	13 (36.1)	2.19 (0.139)	19 (52.8)	3.51 (0.061)	6 (16.7)	0.61 (0.436)
Postgraduates	60	31 (51.7)		43 (71.7)		14 (23.3)	
Age in years							
≤30	61	32 (52.5)	2.96 (0.085)	44 (72.1)	4.17 (0.041)	13 (21.3)	0.023 (0.879)
>30	35	12 (34.3)		18 (51.4)		7 (20)	
Clinical practice hrs per week							
≤20 hours	32	12 (37.5)	1.34 (0.247)	19 (59.4)	0.57 (0.451)	6 (18.8)	0.13 (0.722)
>20 hours	64	32 (50)		43 (67.2)		14(21.9)	

of the respondents felt that proper ethical regulations by the respective professional associations are essential prerequisites to carry out REPs. The importance of such ethical guidelines was also highlighted by Epelman *et al.*^[5]

For newer REPs to become a standard in daily endodontic practice, a robust research backing is essential. Most respondents felt that the clinical applications of these procedures must be preceded by animal testing.

Despite the overall enthusiasm and willingness to perform these procedures, very few of the respondents (18.8%) had any experience with stem cell banking. They felt that the higher cost poses a hurdle for patients and clinicians to accept this treatment modality. However, in their opinions, the cost of regenerative procedures should be higher than conventional approaches. This is in contrast to what was reported in 2013, wherein the endodontic residents of India had responded that the cost of REPs should be the same as that of standard treatments.^[13] This difference in results could be indicative of the increased levels of knowledge of REPs since the previous study as well as the opinion that more training and expertise is required to handle such cases, which would eventually lead to a higher cost of treatment.

In clinical practice, less than half of the participants were performing REPs, most of which were limited to the use of membranes, scaffolds, or bioactive materials. More than half of the participants did not know whether the REPs would have a successful outcome. This indicates a lack of knowledge and clarity of the proper case selection and handling of REPs as well as a perception that these procedures may have a poorer prognosis compared with the conventional methods. In

a longitudinal cohort study, Chan *et al.*^[13] performed REPs on 22 patients. Their results showed a high survival rate (96.4%), clinical success (92.8%), and resolution of apical pathology in 100% of their cases. Significant increases in the average root length and root thickness areas were also observed after 30 months.

More than half of the participants believed that REPs could be valuable in managing various pulpal and periapical pathologies as well as achieving the healing of periradicular bone, the continuation of root development in teeth with an immature apex, revitalization of pulp tissue, and tooth reimplantation. This reflects a positive attitude toward the use of REPs in all the procedures mentioned earlier.

Necrotic immature teeth and traumatized teeth requiring regenerative procedures to be carried out accounted for less than 10% of the cases among the majority of the participants. Less than half of the respondents reported that periradicular lesions accounted for 26–50% of their cases. This indicates a lack of abundance in cases where REPs can be incorporated as a standard line of treatment along with standard endodontic procedures. It could be one of the possible reasons for the slow uptake and acceptance as well as uncertainty in the outcome of REPs among the practicing endodontists.

Half of the participants consider the placement of an apical plug with a bioceramics material and backfilling with obturation material to be the optimum line of treatment for necrotic teeth with an immature apex. This gives us an understanding of the fact that the residents are possibly untrained in performing regenerative endodontic procedures and perhaps are not confident about its results. This implies the need for conducting continuing dental education and training programs on treatment modalities for achieving regeneration of the

Table 6: Multiple logistic regression and adjusted odds ratio showing factors associated with KAP

	Good knowledge		Positive attitude		Positive perception	
	Sig.	Adj. OR (95% CI)	Sig.	Adj. OR (95% CI)	Sig.	Adj. OR (95% CI)
Sex						
Male	–	1		1		1
Female	0.214	1.71 (0.73, 4)	0.006	3.56 (1.45, 8.75)	0.013	5.29 (1.41, 19.84)
Position						
Faculty	–	1		1		1
Postgraduates	0.974	1.03 (0.21, 5.11)	0.872	1.15 (0.22, 6.06)	0.288	3.40 (0.36, 32.42)
Age in years						
≤30	0.443	1.89 (0.37, 9.57)	0.419	1.99 (0.37, 10.61)	0.307	0.31 (0.03, 2.93)
>30	–	1		1		1
Clinical practice hrs per week						
≤20 hours	–	1		1		1
>20 hours	0.306	1.59 (0.65, 3.88)	0.484	1.40 (0.54, 3.61)	0.600	1.37 (0.43, 4.39)

pulp–dentin complex from the basic revascularization method by using blood clotting for more complex and technique-sensitive procedures. This involves the use of various bioengineered materials as well as laboratory-grown tissue-engineered dental pulp constructs and implanting them into disinfected root canals. There are an overwhelming number of materials, techniques, and scaffolds available for REPs, with newer additions every day. Some of the newer scaffolds that have shown promise include decellularized human dental pulp, platelet-rich fibrin, antibiotic-based scaffolds, and synthetic polymers.^[14-17] Various modifications of the current regenerative endodontic protocol have also been attempted, with promising results. The use of REPs, along with apical surgery, has been advocated as an alternative clinical strategy for complex clinical cases with large periapical lesions.^[18] Personalized cell therapy is another exciting avenue that can be further explored. In their case report, Meza *et al.* managed a mature tooth with pulpitis by using autologous cellular therapy with mesenchymal stem cells from inflamed dental pulp and leukocyte platelet-rich fibrin.^[19] The clinical implications and the effectiveness of using different topical antibiotics in REPs also comprise an important aspect that can be explored in further studies.

Stringent safety measures are required for the protection of research participants receiving regenerative endodontic therapies as well as patients at large from receiving dubious regenerative therapies from untrained personnel. In India, the Indian Council of Medical Research has taken the initiative to lay down the guidelines about stem cell research that were revised in 2017.

To protect the patients and health-care providers, both medically and legally, more comprehensive guidelines are required to cover all REPs.

The study observed a higher percentage of postgraduates with good knowledge, positive attitude, and perception compared with the faculty. Further improvement in the KAP could be possible with regularly continuing dental education programs on REPs and its advancements as well as the inclusion of regenerative procedures in the practical curriculum of postgraduates. Only 20.8% of the overall participants had a positive perception that may improve with improved knowledge and attitude.

Further survey research can be conducted to comprehensively evaluate the knowledge of endodontists regarding the various methods, modifications, and newer materials available for regenerative endodontic procedures. A survey of the endodontic residents and faculty in different geographic locations would help

in developing a better perception of the awareness as well as the attitude toward regenerative endodontics globally.

CONCLUSION

This study indicated that less than half of the participants possess sound knowledge and less than one-fourth of the participants have a positive perception toward regenerative endodontics. There is scope for improvement in the KAP. A consensus about the need for more research and training toward REPs is observed among endodontists.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHORS' CONTRIBUTIONS

Arun Mayya and Rajaram Naik: Study conception, data collection, data interpretation, manuscript writing, and manuscript review. Maria Priya Paul and Swathi Amin: Literature search, manuscript preparation, and manuscript review. Shreemathi S. Mayya: Data analysis, interpretation and writing of results. All the authors approved the final version of the manuscript for publication.

ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT

Institutional ethics committee A. J. Institute of Medical Sciences & Research Centre approved this study (AJEC/REV/94/2018, dated 14/07/2018).

PATIENT DECLARATION OF CONSENT

Not applicable.

DATA AVAILABILITY STATEMENT

The data is available on request from the corresponding author.

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