

KNOWLEDGE, ATTITUDES, AND PERCEPTIONS OF BIOACTIVE RESTORATIVE MATERIALS AMONG DENTAL STUDENTS AND DENTISTS IN PAKISTAN: A CROSS-SECTIONAL STUDY

Bushra Malik¹, Vineeta Devi², Darakhshan³, Iqra Muzaffar⁴, Tooba Farhan⁵,
Muhammad Farrukh^{*6}

¹BDS Islamabad Medical and Dental college

²BDS Bibi Aseefa Dental college Larkana

³BDS Women Medical and Dental college Abbottabad

⁴BDS Women Medical and Dental College, Abbottabad

⁵MDS, BDS Dow University of Health Sciences, Karachi

⁶BDS Margalla Institute of Health Sciences, Rawalpindi

¹Bushra.muneeb344@gmail.com, ²Drvineeta60@gmail.com, ³barishnamarwat@gmail.com,
⁴Driqramuzaffar28@gmail.com, ⁵Toobafarhan20@hotmail.com, ⁶drfarrukhbds@gmail.com

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Corresponding Author: *
Muhammad Farrukh

Abstract

Background:

Restorative dentistry has evolved over past few decades, emphasizing on conservative treatment approaches from passive restorative materials to innovation of bioactive materials which remineralize enamel and promote healing of tissues, these materials show high potential to save vitality of tooth.

Objective:

This study will assess the knowledge, awareness and identify barriers related to use of bioactive materials among undergraduate dental students of clinical years and general dentists.

Methods:

A cross-sectional survey was conducted using a structured questionnaire developed on google forms. A total of 210 participants (134; 63.8%) general dentist, while 76 (36.2%) dental students agreed to participate in the survey. Data were analyzed using SPSS software and presented as frequencies and percentages.

Results:

210 participants were included; the majority were general dentist (63.8%) . 20% of participants had experience of more than 5 years among them 87.1 % were familiar with bioactive materials, 80.5% have seen usage of bioactive materials in clinical practice and 91% prefer them over non bioactive materials. 94.8% recognize need of additional training and workshops. With respect to commonly used bioactive materials in practice GIC were being most used (48.6%), followed by CaOH (26.2%) and MTA (22.9%). 73.3% said bioactive materials promote tissue generations while 66.7% observed less post op sensitivity and better healing main challenges in implications of bioactive materials were high cost (41%), lack of availability (21%), and limited long term

clinical evidence (21%).

Conclusion:

Dental professionals show strong awareness, and positive attitude regarding perception of bioactive materials, yet emphasize the need for additional training in material handling and improvements regarding cost effectiveness and accessibility is needed to support successful integration of bioactive materials in regular clinical practice.

INTRODUCTION

This change is due to environmental concerns and new rules to reduce the use of amalgam fillings, as highlighted by the Minamata Convention (7). New materials like bioactive resin composites, now include bioactive glass particles that react and changes pH to fight bacteria (8). Also, nano-bioactive materials have been developed with better surface properties, work more efficiently, natural and have more success of dental treatment (9).

Bioactive materials have many benefits but there are still so many obstacles while using them in a clinical setup. One major challenge is that there is no clear definition of what bioactive material actually means because of that dentists get confused [20]. Also, while lab studies show that bioactive materials can help repair teeth and limit bacterial growth but these materials are not commonly used in clinical practice so there is no long-term data from real patients (9). Other challenges include ambiguity related to mechanical and physical properties, ease of use, aesthetics, and the affordability. All of these can affect patients and dentist's demand. In some cases, bioactive materials may not be as durable or as easy to polish as regular composite materials especially in the areas of mouth that endure a lot of masticatory forces (10).

From an educational perspective not all dental professionals are cognizant enough or trained in using bioactive materials. Studies show even dental professionals are interested in these materials but many dentists do not even feel confident about when to use, what are their limitations or how to use them properly (11). This shows that dental professionals need more training, education and clear guidelines to help their queries.

Given these quick progression and ongoing challenges of bioactive materials, it is high time

Restorative dentistry has evolved significantly over the past few years from their composition to interaction with surrounding tissue. One of the most important and game changing innovation in this domain is bioactive materials which not only restores functions but are also designed to enhance remineralization, surrounding tissue interactions, decrease bacterial activity and even encourage tissue regeneration (1). As dental caries is one of the most common chronic conditions which affect 2.5 billion people, the need for bioactive materials is greater than ever (2).

Bioactive materials in dentistry are very important types of restorative materials that assist the body respond biologically in a very mannered and controlled way at the interface of the material and tissue (3). These bioactive materials includes bioactive glass, calcium silicate-based cements, and resin-modified glass ionomer cements (RMGICs) these bioactive materials are widely used in pulp capping, liner/base applications, endodontic treatments, and as restorative materials (4). The main feature of bioactive material is they chemically react with physiological fluids, which helps create appetite like layer, allowing them to adhere well to dentin and enamel (5). Dentists are choosing materials that act like natural teeth, limiting gaps where bacteria can grow and also promote in releasing ions like calcium, phosphate, and fluoride for remineralization (6). These ions help in repairing tooth and also make it very hard for bacteria to flourish, so restoration can last longer. Also, Biodentine and Theracal LC are becoming popular because these materials are safe for the body and have the potential to heal pulp. This makes them best choices for treating deep cavities and saving the pulp (2). There is a shift from regular composite resins to smart, bioactive materials.

materials, etiology perception and attitude regarding importance of these materials used in clinical practice, knowledge was evaluated through recognition of risk factors & education of these materials. The third involves attitude and acceptance asking participants to reflect on the potential of bioactive materials to enhance in clinical practice with concern about ethical implications. Final section involves utilization of bioactive materials in clinical practice and importance of materials where bioactive materials provide significance benefits. To ensure clarity and content validity the tool was tested on group of dental students these responses were excluded from final analysis, missing responses were managed by a complete case analysis and study was totally review and approved by PRIDE center for research and learning institute committee and data were ensured that it was for research purpose only and were assigned by unique identification codes. No identifying personal information was collected.

This survey was distributed among dental practitioners across various regions in Pakistan. The survey was distributed digitally via professional dental networks, social media platforms, and direct emails. Participants were voluntarily involved and informed consent was obtained electronically before conducting this survey.

Participants recruitment was conducted using convenience non-probability sampling method allowing all eligible individuals. Collecting data were entered and analyzed in SPSS statistics version (26.0) for statistical evaluation and to access the knowledge and perception of bioactive materials in restorative dentistry. Descriptive statistics including frequencies and percentage were calculated to summarize participant's demographics and response pattern. A total 210 participants 134, 63.8% general dentist, 76(36.2%) dental students agreed to participate in this survey.

The required sample size was calculated as 384 to achieve a confidence level of 95% with 5% margin of error to ensure adequate statistical power; however, only 210 participants were recruited due to constraints in student availability during the study period. This shortfall may have reduced the power to detect smaller differences and limits the

to study how dentists are using these materials in their clinical setups. A cross-sectional study can help show how common these materials are in clinical practice and how dental professionals are using them. It can also show differences based on regions, or years of clinical experiences. Such type of studies could help improve dental professionals training and hesitation toward these materials ensuring that restorative practices align with the evolving needs of patients and dental practitioners alike.

Method and Materials:

This research utilized a cross-sectional study observational approach to assess the knowledge and awareness related to bioactive materials in dentistry among dental practitioners of Pakistan.

The Study was conducted nationwide across private and public institutes of different cities of Pakistan including Larkana, Islamabad and Karachi over a period of four months, from 15th May 2025 to 15th September 2025. The study was aimed to assess and identify factors affecting oral health, influencing its integration into the clinical practice.

Inclusion criteria were population including dental professionals, undergraduate dental students, House officers, Post graduate trainees, General dental practitioners and those who were actively involved in clinical practice or training within Pakistan. Whereas, exclusion criteria included those who did not give consent to participate voluntarily, those who declined or showed withdrawal consent

Ethical approval of this study was obtained by pride center for research and learning institute (Ref# PRIDE/EBR/2025/016). The cross-sectional survey was conducted using a self-structured questionnaire developed on google form. The questionnaire design was structured after reviewing prior studies (11, 12), which provided a foundation for adapting the questionnaire while maintaining relevance to the local context, added in supplementary section. No filtered limits and language restrictions were applied during this stage. The questionnaire was divided into four sections the first includes demographic data & professional information such as gender, age group, qualification and City. The second involves awareness and knowledge of bioactive

opportunities for future education and technology adaptation.

Results:

210 respondents participated in this research. As shown in figure 1 73 (34.8%) were male and 137(65.2%) were female. 90 participants (45%) had 0–1 year of experience, 77 (39%) had 1–3 years, 23 (11%) had 3–5 years, and 20 (5%) had more than 5 years of experience. And most were general dentists 134(63.8%), whereas 76 (36.2%) were dental students as shown in Figure 2

generalizability of the findings. Nonetheless, the achieved sample still represents a substantial proportion of the target population and provides meaningful descriptive insights, with results interpreted in light of these limitations. This methodological approach ensured that the study accurately captured the current state of awareness of bioactive materials used in restorative dentistry and its impact on oral health and factors impacting that utilized in dentistry while also identifying gaps and

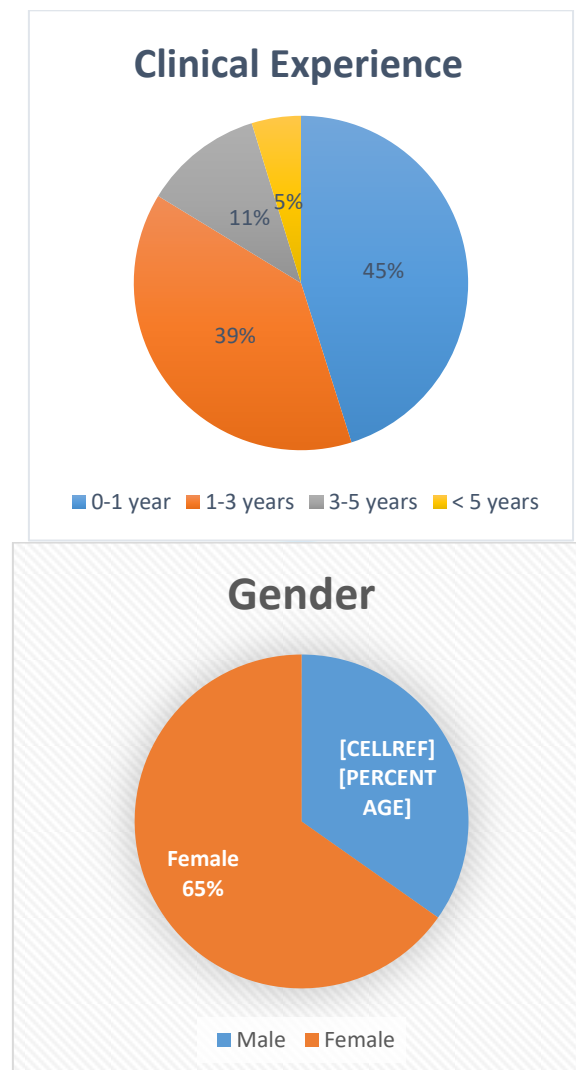


Figure 1 (Pie Chart): Distribution of participants by gender and clinical experience

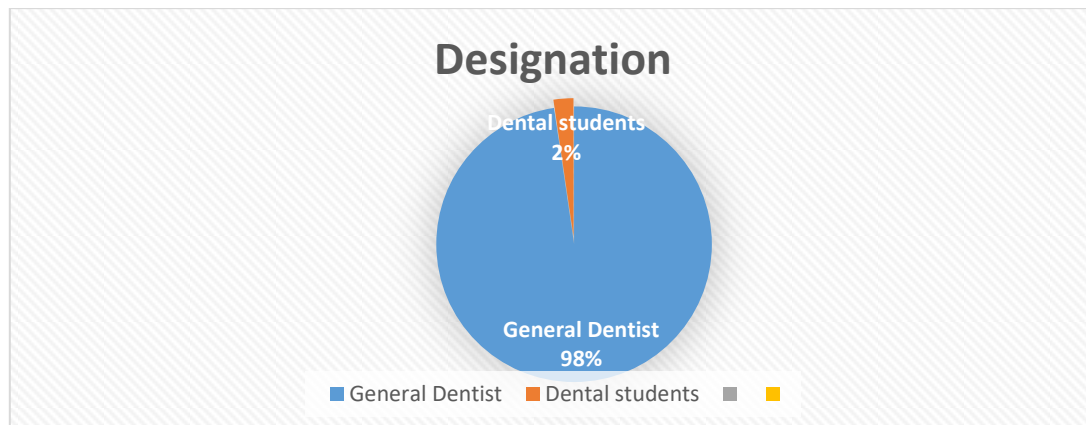


Figure 2 (Pie Chart): Distribution of participants by their designation
After analyzing statistically, the responses were displayed as frequency and percentages as shown in table 1.

TABLE 1. SHOWS THE GOOGLE FORMS QUESTIONS AND THEIR RESPECTIVE RESPONSES AS FREQUENCIES AND PERCENTAGES

ARE YOU FAMILIAR WITH BIOACTIVE MATERIALS?	Have you seen any bioactive material used in your clinical practice?	
	Frequency	Percent
NO	27	12.9
YES	12	87.1
HAVE YOU STUDIED ABOUT BIOACTIVE MATERIALS IN YOUR ACADEMIC YEARS?	Would you prefer bioactive materials over non bioactive materials?	
	Frequency	Percent
NO	39	18.6
YES	171	81.4
DO YOU THINK BIOACTIVE MATERIALS SHOULD BE IMPROVED IN TERMS OF PHYSICAL STRENGTH?	Would additional clinical training or workshops on bioactive materials encourage you to use them more frequently?	
	Frequency	Percent
NO	14	6.7
YES	196	93.3
WHICH OF THE FOLLOWING IS A TYPE OF Which clinical scenario are suitable for bioactive		

BIOACTIVE MATERIAL?			material use?		
	Frequency	Percent		Frequency	Percent
TITANIUM ALLOY	75	35.7	Pulp capping	107	51
G.I.C	19	9	Caries restoration	62	29.5
MTA	101	48.1	Core buildup	20	9.5
GIOMES	15	7.1	Indirect Pulp capping	21	10

According to questionnaire, 191 (91%) respondents prefer bioactive material over non-bioactive materials, and 199 (94.8%) indicating that additional clinical training or workshops on bioactive materials should be encourage to use them more frequently. MTA was the most known (101, 48.1%), followed by titanium alloy (75, 35.7%), G.L.C (19, 9%) and GIOMES (15, 7.1%). Clinically, pulp capping was the most suitable scenario (107, 51%), then caries restoration (62, 29.5%), indirect pulp capping (21, 10%), and core buildup (20, 9.5%).

Table 1 summarizes that 183 (87.1%) were conscious about bioactive materials, and 27(12.9%) were unconscious about bioactive materials. According to questionnaire, 169 (80.5%) have seen bioactive materials used in clinical practice and 41(19.5%) have not seen in clinical setup. Additionally, 171 (81.4%) studied bioactive materials during their academic years. According to 196 (93.3%) respondents, bioactive materials should be improved in terms of physical strength.

TABLE 2. SHOWS THE GOOGLE FORMS QUESTIONS AND THEIR RESPECTIVE RESPONSES AS FREQUENCIES AND PERCENTAGES

HOW CAN BIOACTIVE MATERIALS IMPROVE DENTAL RESTORATIONS?			What makes bioactive dental materials special?		
	Frequency	Percent		Frequency	Percent
BY ENHANCING MECHANICAL PROPERTIES	41	19.5	Aesthetic appeal	1	2.4
BY PROMOTING TISSUE REGENERATION	154	73.3	Ability to promote healing and regeneration	175	83.3
BY IMPROVING AESTHETICS	6	2.9	High mechanical strength	18	8.6
BY REDUCING TREATMENT TIME	9	4.3	Low cost	5	5.7
WHICH BIOACTIVE MATERIAL IS COMMONLY	How do bioactive materials help prevent tooth decay?				

USED FOR ROOT CANAL TREATMENTS?					
FREQUENCY			Frequency		
PERCENTAGE			Percentage		
G.I.C	60	28.6	By releasing fluoride ions	152	72.4
CALCIUM SILICATE BASED MATERIALS	113	53.8	By providing a physical barrier	33	15.7
NANOCOMPOSITES	15	7.1	By promoting Gum health	9	4.3
BIO CERAMICS	22	10.5	By reducing bacterial growth	16	7.6
WHAT DO YOU THINK BIOACTIVE MATERIALS ARE SUITABLE FOR WHICH PROCEDURES?			How often you use bioactive materials in your setting?		
FREQUENCY			Frequency		
PERCENTAGE			Percentage		
DECIDUOUS TEETH	10	4.8	Very frequently	100	47.6
PERMANENT TEETH	51	24.3	Occasionally	52	24.8
IMMATURE PERMANENT TEETH	12	5.7	Rarely	48	22.9
ALL	137	65.2	Never	10	4.8

health benefits. According to 100 respondents (47.6%) bioactive materials used very frequently, 52 (24.8%) occasionally, 48 (22.9%) rarely, and 10 (4.8%) never. According to the 113(53.8%) respondents calcium silicate-based material is commonly used for root canal treatment, G.I.C 60(28.6%), bioceramics 22(10.5%) and nanocomposite 15(7.1%). 65.2% believed that all teeth are suitable for bioactive materials, 4.8% believed they are suitable for deciduous teeth, while 24.3% believed they are suitable for permanent teeth and 5.7%, considered them suitable for immature permanent teeth.

Table 2 highlights that the potential of bioactive materials in enhancing dental restorations, with 154 respondents (73.3%) believed that bioactive materials promote tissue regeneration, 41 (19.5%) indicated improved mechanical properties, 6 (2.9%) aesthetics, and 9 (4.3%) reduced treatment time. According to 175 respondents (83.3%) bioactive materials are special for their ability to heal and promote healing, followed by 18 (8.6%) high mechanical strength, 1 (2.4%) aesthetic appeal, and 5 (5.7%) low cost. In preventing tooth decay, 152 respondents (72.4%) mentioned the release of fluoride ions, while 33 (15.7%) mentioned the physical barrier, 16 (7.6%) mentioned reduced bacterial growth, and 9 (4.3%) recognized gum

Table 3. Shows the Google Forms questions and their respective responses as frequencies and percentages

WHICH BIOACTIVE MATERIALS DO YOU USE IN DAILY PRACTICE?			WHICH FACTOR MOST INFLUENCES YOUR CHOICE TO USE BIOACTIVE MATERIALS IN RESTORATIVE PROCEDURES?		
FREQUENCY PERCENTAGE			Frequency percentage		
G.I.C	102	48.6	Ease of use & handling	33	15.7
MTA	48	22.9	Patient demand	14	6.7
CAOH	55	26.2	Clinical success rate & healing potential	143	68.1
BIODENTIN	5	2.4	Recommendations from mentors/literature	20	9.5
HOW CONFIDENT ARE YOU IN SELECTING THE APPROPRIATE BIOACTIVE MATERIAL FOR A SPECIFIC CLINICAL CASE?			Have you observed any significant difference in patient outcomes when using bioactive materials versus conventional ones?		
FREQUENCY PERCENTAGE			Frequency Percentage		
VERY CONFIDENT – I UNDERSTAND INDICATIONS WELL	49	23.3	Yes – better healing and less post-op sensitivity	140	66.7
SOMEWHAT CONFIDENT – I RELY ON GUIDELINES OR MENTORS	98	46.7	No noticeable difference	28	13.3
NOT VERY CONFIDENT – I STILL NEED MORE TRAINING	61	29.0	Not applicable – I haven’t used them enough to compare	40	19.0
NOT CONFIDENT AT ALL – I AVOID USING THEM DUE TO UNCERTAINTY	2	1.0	Same as conventional ones	2	1.0
IN YOUR OPINION, WHICH PROPERTY MAKES A MATERIAL TRULY “BIOACTIVE”?			How often do you think bioactive materials are actually used in regular clinical practice?		
			Frequency percentage		

FREQUENCY		PERCENTAGE			
ION RELEASE	16	7.6	Very often	78	37.1
ANTIBACTERIAL EFFECT	12	5.7	Sometimes	90	42.9
REMINERALIZATION			Rarely	36	17.1
POTENTIAL	31	14.8			
ALL OF THE ABOVE	157	71.9	Almost never	6	2.9
DO YOU THINK PATIENTS CARE WHETHER A MATERIAL IS BIOACTIVE, OR DO THEY JUST WANT THE RESTORATION TO LOOK GOOD?			What challenges do you face (or foresee) in incorporating bioactive materials into routine clinical practice?		
PERCENTAGE		FREQUENCY		Frequency	Percentage
PATIENTS CARE ABOUT			High cost	86	41.0
FUNCTION AND HEALTH	77	36.7			
PATIENTS ONLY CARE			Lack of availability	44	21
ABOUT APPEARANCE	32	15.2			
DEPENDS ON THE PATIENT	94	44.8	Limited clinical evidence	44	21
NOT SURE	7	3.3	Handling difficulty	36	17.1

bioactivity comes from a combination of ion release, remineralization, and antibacterial effects, 14.8% attributed to remineralization potential, 7.6 % to ion release, 5.7% to antibacterial effect. 42.9% respondents reported using bioactive materials sometimes, and 37.1% very often, 17.1% rarely and 2.9% almost never. According to 44.8% felt it depends on patient, while 36.7% believed patients care about function and health and 15.2 % felt patient only care about appearance. The main challenges were high cost (41%), limited availability (21%), and insufficient clinical evidence (21%) and 17.1% handling difficulty.

Discussion:

The findings of this study show that the majority of the participants (87.1%) were familiar with bioactive restorative materials and (91%) preferred it over non-bioactive restorative materials.

Table 3 shows that (48.6%) Glass Ionomer Cements used most commonly as a bioactive material, followed by calcium hydroxide (26.2%) and MTA (22.9%), with Bio dentin used rarely (2.4%). The main factor influencing the choice of material was clinical success and healing potential (68.1%), followed by 15.7% ease of use and handling, 9.5% recommendation from mentor and 6.7% patient demand. 23.3% were very confident while selecting the appropriate bioactive material for a specific clinical case, while 46.7% were somewhat confident, 29% respondents were not very confident and need more training and 1.0% were not confident at all. According to (66.7%) better healing and reduced post-operative sensitivity was seen when using bioactive materials, followed by 13.3% no noticeable difference, 19% respondents never used enough bioactive materials and 1% respondents believed bioactive materials as same as conventional ones. A majority (71.9%) believe that true

of bioactive restorative materials. Corresponding outcome have been reported, where GIC is widely used, might be because of release of ions (fluoride ion) and economical convenience, while Ca (OH)₂ and MTA (mineral trioxide aggregate) are preferred in vital pulp therapy with additional regenerative procedures (17, 18). Similarly, participants in the above present study also focused on the bioactive restorative material's biological benefits, reported (73.3%) tissue regenerative and (66.7%) observing reduce post-operative sensitivity uncovering the line up with previous reported studies that bioactive materials promote remineralization and improve tissue healing through the release of ions (19, 20). In spite of these favorable impression and optimistic review, there are still challenges that remain apparent. Major barriers and challenges are high cost (41%), limited availability (21%), lack in evidence of long term clinical use (21%). Almost similar hurdles have been repeated in systemic reviews which stated that while bioactive restorative materials have commendatory biological aspects, their mechanical limitations and inadequate clinical trials hinder the general acceptance and widespread support (21, 22). These difficulties and hurdles emphasize the need for the ongoing research to improve properties of bioactive materials, focus on budget, make it economical and compelling strong clinical finding and evidence from them. Latest article further added strain, that the innovative biomaterial must be accompanied by strategies to accessibility and clinical-friendly application to achieve successful integration (23). This gap in knowledge underscores the necessity for integrating modern dental technologies and material science more robustly into the educational syllabus, as has been recently advocated for in digital dentistry. The call for curriculum modernization to better prepare future dentists is a recurring theme in contemporary dental education research (24).

The limitation of our study was that, the previous calculated sample was 380, as we are unable to achieve this amount of feedback. Therefore, the Finding may not fully represent the whole population. Future studies with higher population size is recommended to authenticate above findings. Furthermore, it

The above data indicates that the response highly demonstrates a robust trend regarding awareness, knowledge and positive perception among dental professionals, which is coherent with current literature, highlighting the increased acceptance of bioactive restorative materials in restorative dentistry (13, 14).

Similarly, the majority of the participants (87.1%) show positive feedback and acceptance to bioactive restorative materials in dentistry consistent with Hasanain et al ;(2021) (11), who reported a similar feedback and preceptor among recent dental professionals.

Shelke et al. (12) in 2025 also conducted a research on bioactive materials in Saudi Arabia, and found moderate awareness and minimal adoption among practitioners and students, with no correlation between clinical experience and use

However, based on the findings presented above indicating high level of awareness among dental professionals it necessarily does not specify the prevalent/common clinical use, suggesting other hurdles may influence the adaptation and use of bioactive restorative materials.

Almost all participants (94.8%) concede the need for additional workshops, trainings and arrangement of seminars for better understanding and clinical use of bioactive restorative materials. This finding foregrounds a censorious gap between knowledge and clinical application. Correlated to our study and findings previous studies have also stated that while dental professionals are well aware of biological advantages of bioactive restorative materials, they often review difficulties in handling, lack of confidence in long-term performance of bioactive materials (15, 16). Therefore, to address those shortcomings, workshops with hands-on sessions, and seminars should be conducted to minimize the gap, and therefore support the comprehensive integration of these materials into routine clinical practice.

In terms of usage, Glass ionomers cement GIC (48.6%) appeared as the most commonly used bioactive restorative material, followed by calcium hydroxide CaOH₂ (26.2%), and MTA is the most recognized (22.9) followed by titanium alloy this data indicates well known clinical history and knowledge, and availability

probability sampling may have introduced evidence, reducing cost and training opportunities will be prerequisites for the successful adaptation of bioactive restorative material in clinical practice.

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