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ORIGINAL ARTICLE

Evaluation of Awareness and Performance of General Dentists in Isfahan Regarding Biomimetic Materials Used in Dentistry

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Abstract

Background: Today, biomimetic materials hold a special place in dentistry due to their adhesion to tooth structure and their proximity to tooth structures in both function and aesthetics. This study aimed to evaluate the awareness and performance of general dentist graduates of Isfahan, Kashan, and Isfahan Islamic Azad Universities in relation to the biomimetic materials used in dentistry.

Materials and methods: In this cross-sectional study, 190 general dentists in Isfahan were selected. A valid and reliable questionnaire composed of three sections: demographic information, level of awareness, and performance assessment was used. The questionnaires were distributed to general dentists via an electronic form. The collected data were analyzed using Spearman, Mann-Whitney, and Kruskal-Wallis statistical tests (α=0.05).

Results: Out of 190 participants, 102 dentists (53.7%) reported being aware of biomimetic materials used in conservative and endodontic treatments, while 88 dentists (46.3%) reported no awareness. 32.6% of the participants reported using biomimetic materials in their clinical practice, whilst only 29.04% of them reported receiving specific training on how to use these materials, with the majority having acquired their education during their undergraduate dental studies.

Conclusion: The level of awareness and performance of general dentists in Isfahan was not at a satisfying level, which indicates a special focus on teaching biomimetic materials in dental education programs.

Keywords: Knowledge; Biomimetic Materials; Dentists; Clinical Competence

Introduction

In recent decades, restorative dentistry has seen significant advancements due to the development of adhesive restorative materials, a better understanding of the caries process, and progress in dental science (1). Traditional restorative methods for treating dental caries generally overlook the underlying cause of the disease. As a result, a cycle of continuous tissue removal and restoration is created, which ultimately leads to increased cavity size and structural compromise of the tooth. This recognition has contributed to the growing acceptance of minimally invasive dentistry (MID) as a modern approach to managing caries (2,3). Unlike traditional methods, MID focuses on prevention, maximal preservation of healthy tooth structure, the use of adhesive materials,

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and evidence-based clinical decision-making. The core philosophy of MID supports the preservation of tissues and promotes the potential for remineralization of demineralized hydroxyapatite (HA) under favorable conditions (4, 5). Adhesive materials are integral to MID due to their ability to form a durable bond with dental substrates without necessitating extensive mechanical preparation (6,7). In conservative dentistry, biomimetic materials are used for restoration, repair, and regeneration. These materials are designed to mimic biological structures and functions, inducing responses such as hydroxyapatite formation and supporting pulp vitality and tissue healing (8).

The term biomimetic was introduced by biomedical engineer Otto Schmitt in the 1950s (5, 9). It is derived from bio, meaning life, and mimetic, from mimicking, indicating the imitation of natural biological processes (9). In restorative dentistry, biomimetic principles guide the development and use of materials that replicate the physical, chemical, and functional characteristics of natural dental tissues. Various bioactive compounds—such as micro- and nano-hydroxyapatite, tricalcium phosphate, tri-mineral oxides, casein phosphopeptides, and bioactive glasses have attracted considerable interest due to their high biocompatibility, biomimetic potential, and regenerative capabilities. Clinically, the biomimetic approach in dentistry aims to restore dentin and enamel in a way that closely simulates the tooth's natural histological architecture, biomechanics, and esthetics (10, 11). Adhesive restorative systems exemplify a conservative approach by allowing for minimal intervention in cavity designs while effectively restoring the tooth’s form and function (12,13). The performance of these bioactive materials is closely tied to their ability to create a protective layer upon contact with phosphate-containing physiological fluids (14-16). This process generally includes a chemical reaction between calcium and phosphate ions, leading to the formation and growth of hydroxyapatite crystals. This mechanism is crucial for the regenerative functions of many biomimetic systems, including bioactive glass-ceramics. (17).

Singer et al. (18), in a comprehensive review, emphasized that biomimetic dentistry holds the potential to revolutionize clinical practice by enabling the functional repair and biological replacement of diseased hard and soft dental tissues. As the field advances, restorative dentistry is expected to shift away from inert, passive restorative materials toward bioactive systems capable of promoting tissue regeneration. Innovations in tissue engineering, particularly those targeting the regeneration of the dentin–pulp complex through biomimetic strategies, may represent a significant advancement in operative and endodontic therapies.

In a study conducted by Jaju and Nasim (17), the knowledge and perceptions of biomimetic materials among postgraduate students, endodontists, interns, and general dental practitioners in India were evaluated. The findings revealed that most participants gained their knowledge from postgraduate training. The authors recommended integrating biomimetic concepts into undergraduate dental education to enhance early exposure and clinical readiness. Furthermore, the limited availability and high cost of biomimetic materials were identified as significant barriers to their adoption in routine dental practice.

Considering the increasing integration of biomimetic materials into conservative and endodontic procedures, raising awareness among practitioners is critical to improving clinical outcomes and advancing the standard of care. This study aimed to evaluate the awareness and performance of general dentist graduates of Isfahan, Kashan and Isfahan Islamic Azad Universities in relation to the biomimetic materials used in dentistry.

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Materials and Methods

This cross-sectional descriptive-analytical study was conducted among 190 general dental practitioners employed in private offices, private clinics, and governmental dental centers in Isfahan using a single-stage sampling method. Dentists who declined to complete the questionnaire or submitted incomplete responses were excluded from the study

The data was collected using a structured questionnaire consisting of three sections. The first section collected demographic information, including age, clinical experience, and place of graduation. The second section comprised 21 multiple-choice items designed to evaluate dentists' awareness of biomimetic materials utilized in conservative and endodontic procedures. Awareness levels were determined based on the percentage of correct responses: <25% (poor), 25–50% (moderate–low), 50–75% (moderate–high), and 75–100% (good). The third section included 15 multiple-choice items assessing the self-reported clinical performance of general dentists in applying biomimetic materials in restorative and root canal treatments.

Face validity was assessed qualitatively, with attention to item clarity, grammatical accuracy, conceptual coherence, and visual layout. Validation was achieved through expert review by two dental specialists, complemented by feedback from 10 faculty members from the Departments of Conservative Dentistry and Endodontics at Islamic Azad University, Khorasgan Branch. Quantitative measures of content validity demonstrated strong results, with a content validity ratio (CVR 0.96) and content validity index (CVI 0.98) calculated and confirmed (19, 20). Reliability was confirmed via the test–retest method for temporal stability and was confirmed through the test-retest method to ensure stability over time and through Cronbach's alpha coefficient to assess internal consistency ($\alpha = 0.948$), indicating excellent reliability (21).

The finalized questionnaire was developed on the Perseline platform and disseminated electronically via professional networks and social media platforms, including Instagram and WhatsApp, targeting general practitioners in Isfahan. Collected responses were analyzed for frequency distribution and percentage scores per item.

Normality of data distribution was evaluated using the Kolmogorov–Smirnov test. Subsequent statistical analysis was performed using non-parametric tests—Spearman's rank correlation, Mann–Whitney U, and Kruskal–Wallis tests implemented in SPSS version 26 with a significance level set at 5%

Results

Among the 190 participating general dentists, 52 (27.4%) were under the age of 25, 112 (58.9%) were between 25 and 30 years old, and 26 (13.7%) were over the age of 30. In terms of professional experience, 156 participants (81.6%) had less than five years of clinical experience, whereas 35 (18.4%) had more than five years of experience (Table 1).

Table1. Frequency distribution of research units by age group and work experience

Variable	Group	N	Percentage	Mean ± SD
Age	under the age of 25	52	27.4	28.40 ±6.47
	25 and 30 years old	112	58.9	
	over 30 years	26	13.7	
work experience	less than 5 years	155	81.6	3.47±5.88
	more than 5 years	35	18.4	

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In evaluating the dentists' awareness of biomimetic materials used in restorative and endodontic procedures, 88 dentists (46.3%) reported no awareness, while 102 (53.7%) indicated some level of familiarity with these materials. Among the knowledge items assessed, the highest correct response rate (90.5%) pertained to the statement regarding "the higher radiopacity of MTA compared to its disadvantages." In contrast, the lowest awareness (12.8%) was observed for the items "the vascular property as one of the benefits of MTA" and "biomimetic materials are substances that stimulate dental tissues" (Table 2).

Table 2. Distribution of frequency of responses from dentists regarding awareness questions about the use of biomimetic materials.

Question N.	Question	True Answer	False Answer
1	Biomimetic materials are materials that mimic dental materials.	12.80	87.2
2	Biomimetic materials are materials used in apexogenesis and apexification.	41.10	58.9
3	Biomimetic materials are materials to which bioactive materials have been added.	63.20	36.8
4	Biomimetic materials are materials that have the ability to self-repair.	68.40	31.6
5	Biodentine is considered a biomimetic material.	49.50	50.5
6	GIC is considered a biomimetic material.	30.50	69.5
7	MTA is considered a biomimetic material.	52.60	47.4
8	Calcium hydroxide is considered a biomimetic material.	29.50	70.5
9	Pulp capping is an application of MTA.	83.20	16.8
10	Apexification is an application of MTA.	85.30	14.7
11	The technical advantages of working with the material are the benefits of MTA.	55.80	44.2
12	The vascular property is a benefit of MTA.	12.80	87.2
13	Higher radiopacity is a disadvantage of MTA.	90.50	9.5
14	Alkaline pH is a disadvantage of MTA.	83.20	16.8
15	Long setting time is a disadvantage of MTA.	75.70	24.3
16	Setting in the presence of moisture is a disadvantage of MTA.	72.00	28
17	Discoloration is a disadvantage of MTA.	65.60	34.4
18	Class V cavity restoration is an application of bioactive glass in conservative dentistry.	74.60	25.4
19	Treatment of dentinal hypersensitivity is an application of bioactive glass in conservative dentistry.	74.60	25.4
20	Pit and fissure sealants are an application of bioactive glass in conservative dentistry.	50.30	49.7
21	The use of bioactive glass after bleaching stained teeth is an application in conservative dentistry.	25.40	74.6

The Spearman correlation test revealed no statistically significant association between age and dentists' awareness of biomimetic materials ($p = 0.070$). In

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contrast, a significant positive correlation was observed between years of work experience and awareness ($p = 0.021$), indicating that awareness levels increased with professional experience.

The Kruskal–Wallis test demonstrated a significant difference in awareness scores based on the university of graduation ($p < 0.001$). Post-hoc analysis using the Mann–Whitney U test with Bonferroni adjustment indicated no significant difference in awareness scores between graduates of Islamic Azad University of Isfahan and Isfahan University of Medical Sciences ($p > 0.05$). However, the awareness levels among graduates from these two universities were significantly higher than those of graduates from Kashan University and other institutions ($p < 0.05$).

In terms of practical application, 32.6% of the participating general dentists reported using biomimetic materials in their clinical practice. Despite this, only 29.04% had received formal education or training on the use of such materials. Among those trained, 56% had received instruction during their undergraduate dental education, while 22% had accessed online resources and 22% had participated in postgraduate or continuing education programs (Table 3).

Table 3. Distribution of dentists based on the use of biomimetic materials and their training methods regarding these materials.

Variable	Groups	N	Percentage
"Dentists' use of biomimetic materials"	No	128	67.40
	Yes	62	32.60
"Training in the use of biomimetic materials"	No	44	70.96
	Yes	18	29.04
"Method of receiving training"	Through online resources	4	22.20
	During the general course at the university	10	55.60
	During post-graduation training courses	4	22.20

Based on the results of the Mann–Whitney U test, no statistically significant difference was observed in the age of dentists about their use or non-use of biomimetic materials ($p = 0.191$). Similarly, no significant difference was found in work experience between users and non-users of biomimetic materials ($p = 0.053$). However, there was evidence suggesting that the work experience was higher in dentists using biomimetic materials ($p<0.1$).

In assessing the relationship between awareness and clinical performance, the Mann–Whitney U test revealed that dentists who used biomimetic materials had significantly higher awareness scores compared to those who did not ($p < 0.001$) (Table 4).

Table 4. Comparison of the mean awareness scores of general dentists regarding biomimetic materials based on their performance in using these materials.

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Variable	Use of biomimetic materials	N	Mean± SD	P value
Awareness about biomimetic materials	No	128	11.23±2.77	<0.001
	Yes	62	13.39±2.21	

Furthermore, the Kruskal–Wallis test indicated a significant difference in awareness scores based on the frequency of biomimetic material use ($p = 0.025$). Post-hoc analysis using the Mann–Whitney U test with Bonferroni adjustment demonstrated that dentists who used biomimetic materials only once per month had significantly lower awareness scores compared to those who used them more frequently (2–5 times, 5–7 times, or 7–10 times per month) ($p < 0.05$) (Table 5)

Table 5. Comparison of the mean awareness scores of general dentists regarding biomimetic materials based on their performance in using these materials.

Variable	The extent of use of biomimetic materials	N	Mean± SD	P value
Awareness about biomimetic materials	One time per month	8	11.00±2.73	0.025
	2 to 5 times per month	38	13.84±2.09	
	5 to 7 times per month	8	13.00±1.69	
	7 to 10 times per month	8	14.00±1.07	

Discussion

The current study showed that the average awareness score of general dentists regarding biomimetic materials was 11.94 out of 18. This indicates a moderately above-average level of awareness, with an overall awareness percentage of 56.85%. Most participants (91.1%) exhibited an average level of awareness, while only a small proportion showed good (4.8%) or poor (0.5%) awareness. These findings are in contrast with those of Mirsiaghi et al. (22) in the UK, who reported poor awareness among dentists regarding minimally invasive dentistry (MID). Conversely, Das and Nasim (23) in India found that 75% of their participants were aware of biomimetic materials, suggesting a higher awareness level in their population. The observed discrepancies across studies may be attributed to variations in dental curricula and the extent of research emphasis in each country.

When participants were specifically asked about the use of biomimetic materials in conservative dentistry and endodontics, 53.7% of participants responded positively. This result is somewhat consistent with the findings of Mirsiaghi et al. (69%), but it is lower than the positive response rates reported by Das and Nasim (93.3%) and Katz et al. (82.1%) in Brazil. These differences may reflect regional variations in academic exposure and clinical access to biomimetic materials.

The awareness rate concerning the advantages and disadvantages of mineral trioxide aggregate (MTA) was 65%, compared to 80% in the study by Das and Nasim (23). While participants demonstrated good knowledge of MTA's established properties, awareness of its newer characteristics such as angiogenic potential was notably lower. This may reflect insufficient engagement with recent scientific literature or limited access to continuing education on emerging biomaterials.

No significant association was found between dentists' age and their awareness, which aligns with the findings of Rayapudi et al. (24) and Shah et al. (25). However, there was a significant positive relationship

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between clinical work experience and awareness. This supports the trends observed in the studies by Rayapudi and Shah, but contrasts with the findings of Katz et al., who reported no such relationship.

Regarding the educational background of participants, no significant difference was observed in awareness levels between graduates of Islamic Azad University of Isfahan and Isfahan University of Medical Sciences. However, graduates from these two institutions had significantly higher awareness than those from Kashan University and other schools. This difference may relate to disparities in educational quality, institutional resources, and the higher number of graduates from the leading institutions.

Only 32.6% of dentists in this study reported using biomimetic materials, and just 20.4% had received formal training in their application. Among those trained, the majority received instruction during undergraduate education, while others relied on online sources or postgraduate courses. This finding contrasts with the results presented by Shah et al. (25), which indicated that 40.09% of participants reported a lack of prior education in minimally invasive dentistry (MID)-related training during their dental education.

Despite growing interest in biomimetic materials, their actual use in practice remains limited. Of the 190 respondents, only 62 reported using such materials, with most (61%) using them 2–5 times per month. This is lower than the 70.3% usage frequency reported by Jaju and Nasim. Among users, calcium hydroxide (61%) and MTA (29%) were the most commonly applied materials, likely due to their longstanding presence in dental practice. MTA was the preferred choice for pulp capping (58%), followed by zinc oxide (13%) and Biodentine (10%). Despite Biodentine's superior clinical performance and favorable properties, its limited availability—likely due to international sanctions may explain its low usage in Iran.

In the treatment of root perforations, MTA was reported as the most successful material (83.9%), further confirming its established clinical reliability. However, overall awareness and performance levels among dentists were suboptimal, particularly given the high proportion of recently graduated and younger practitioners. This highlights deficiencies in the current dental education system and underlines the need for enhanced curricular emphasis on biomimetic concepts.

Furthermore, the study identified a significant association between awareness and clinical performance, suggesting that increased knowledge directly contributes to improved use of biomimetic materials. Ghoul et al. (26) in Libya reported similar obstacles, such as lack of knowledge, high costs, and limited availability, as major impediments to adoption. As such, the integration of biomimetic dentistry into both undergraduate curricula and continuing education programs is essential to equip future dentists with the necessary competencies for modern, biologically driven restorative care

Conclusion

The level of awareness and performance of general dentists in Isfahan city was insufficient highlighting a need for a special focus on teaching biomimetic materials in dental education programs.

Conflict of Interests:

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial, or non-financial in this article

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