

Original article

Knowledge, Attitudes, and Practice of Biomimetic Dentistry among General Dentists and Specialists in Tripoli, Libya.

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ABSTRACT:

Aim: The aim of this study was to evaluate knowledge, attitudes and Practice of biomimetic dentistry among general dentists and specialists in Tripoli, Libya. **Methods:** The questionnaire was designed to assess knowledge and opinion toward biomimetic dentistry among Libyan dentists in Tripoli, the questionnaire was consisted of 21 yes, no questions about biomimetic some biomimetic materials and techniques. **Results:** showed highest level of awareness has been founded among specialists (90.9%) and the lowest level was among general dentists, with 76.2% being aware of biomimetic materials. The percentage of awareness tends to increase with increase in years of experience. The study revealed that high percentages of dentists have a good knowledge about biomimetic materials and high percentage of them prefer using biomimetic materials. The study revealed there is an under-utilization of some biomimetic materials and techniques. **Conclusion:** The present study concludes that the lack of knowledge, unavailability and high cost constitute major obstacles to the use of biomimetic materials when compared to conventional methods. To fill these gaps, seamless education on biomimetic methodologies should be implemented into the curriculum of undergraduate dental studies. In addition, providing particular postgraduate courses about biomimetic dentistry would boost dentist ability and knowledge to use these recent techniques in their regular practice.

Keywords: Biomimetic Materials, Stress-Reduce, Bond Maximizing Protocol.

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الهدف: كان الهدف من هذه الدراسة هو تقييم المعرفة والمواقف والممارسة في طب الأسنان المحاكى الحيوي بين أطباء الأسنان العاميين والمتخصصين في طرابلس، ليبيا. **طرق الدراسة:** تم تصميم الاستبيان لتقييم المعرفة والرأي حول طب الأسنان المحاكاة الحيوية بين أطباء الأسنان الليبيين في طرابلس، وكان الاستبيان يتكون من 21 سؤال نعم، لا حول المحاكاة الحيوية لبعض المواد والتقنيات الحيوية. **النتائج:** أظهرت أن أعلى مستوى للوعي كان بين المتخصصين (90.9%) وكان أدنى مستوى بين أطباء الأسنان العاميين، حيث كان 76.2% على دراية بالمواد المحاكاة الحيوية. وتميل نسبة الوعي إلى الزيادة مع زيادة سنوات الخبرة. وكشفت الدراسة أن نسب عالية من أطباء الأسنان لديهم معرفة جيدة بالمواد المحاكاة الحيوية وأن نسبة عالية منهم يفضلون استخدام المواد المحاكاة الحيوية. وكشفت الدراسة عن وجود نقص في استخدام بعض المواد والتقنيات المحاكاة الحيوية. **الخلاصة:** خلصت الدراسة الحالية إلى أن نقص المعرفة وعدم التوافر والتكلفة العالية تشكل عقبات رئيسية أمام استخدام المواد المحاكاة الحيوية بالمقارنة مع الطرق التقليدية. لملء هذه الفجوات، ينبغي تنفيذ التعليم السلس حول منهجيات المحاكاة الحيوية في المناهج الدراسية لدراسات طب الأسنان الجامعية. بالإضافة إلى ذلك، فإن توفير دورات معينة للدراسات العليا حول طب الأسنان المحاكى الحيوي من شأنه أن يعزز قدرة طبيب الأسنان ومعرفة لاستخدام هذه التقنيات الحديثة في ممارساته المنتظمة.

INTRODUCTION

The word 'biomimetic' is derived from a Latin word, where "bio" means life, and "mimetic" means imitation or mimicking., biomimetic is the art of mimicking nature [1]. The term was first coined by Otto Schmitt in 1969 and can be defined as "the study of formation, structure or function of biologically produced substances and materials and biological mechanisms and processes, for the purpose of synthesizing similar products by artificial mechanisms that mimic natural structures" [2]. A material fabricated by Biomimetic technique based on natural process found in biological systems is called a Biomimetic material [3]. Biomimetics in restorative dentistry was facilitated and supported by the developments and evolution in dental composite resins, clinical adhesives and dental ceramic. Utilization of adhesive protocols would eliminate the need for extensive tooth destructive mechanical retentive features which would enable tooth conservation to a larger extent satisfying one of the main objectives of biomimetic restorative dentistry [1]. Glass ionomer cements (GIC), composites, Mineral Trioxide Aggregate (MTA), and the innovative Biodentine are among the minimally invasive materials designed to replace dentin, Advantages of GIC include adhesion to enamel and dentin and release of fluoride, calcium and aluminium ions and the effect of rechargeability which means uptake of fluoride from the environment and release of fluoride when the fluoride concentration is low in the immediate environment of the GIC. While traditionally glass ionomers have been used in lamination or sandwich techniques to replace the bulk of dentine with composites on top to bond to enamel, but recently Biodentine has been advocated which is considered to be more biomimetic and bioactive than glass ionomers cements [4].

Mineral Trioxide Aggregate, a bio-ceramic material developed by Mahmood Torabinejad, is notable for its high pH, fostering regeneration of the periodontal ligament, dentinal bridge formation, biomineralization, and antimicrobial activity [5].

Biodentine, another calcium-silicate-based material, has gained prominence for its diverse clinical applications, including root perforations, apexification, resorptions, retrograde fillings, pulp capping, and dentine replacement. Notably, Biodentine exhibits a shorter setting time and superior handling characteristics compared to MTA, its bioactive properties positively influence vital pulp cells, stimulating tertiary dentin formation and promoting reparative dentin in direct contact with vital pulp tissue [2].

Endosequence root repair material (ERRM) delivered as a premixed mouldable putty or as a preloaded paste in a syringe with delivery tips for intracanal placement. It contains calcium phosphate monobasic, calcium silicates, zirconium oxide and tantalum oxide, inside dentinal tubules, ERRM forms tag-like structures. it allows gingival fibroblasts to grow on their surface [5].

The search for newer materials will never end, but the advent of bioceramic technology has the potential to be a game changer in endodontics. Bioceramic sealers are currently being extensively researched based on sound scientific evidence, biocompatible, bioactive, and antibacterial hydraulic calcium silicate materials that slightly expand upon setting and remain dimensionally stable in combination with single-cone obturation can replace lateral condensation as the most effective endodontic sealing technique [6]. Bioceramic Gutta-Percha, another advancement, involves Gutta-Percha cones impregnated and coated with bioceramic nanoparticles, ensuring tip and taper accuracy through laser verification. This innovative combination allows for "three-dimensional bonded obturation [5].

Biomimetic restorative protocols, a cornerstone of modern dentistry, are categorized into stress-reducing and bond-maximizing protocols ,Stress reducing protocols include the usage of indirect restorations (to reduce e the development of compressive stress), replacing the lost dentine with composite of similar modulus of elasticity so as to help absorb and dissipate the stress evenly, use of fibers on the pulpal

floor and axial wall to cause hindrance to crack propagation), capping of the cusp thinner than 2mm, converting the tensile forces in to vertical compressive forces [1]. Bond maximization protocols on the other side of the spectrum involves using of a good bonding agent, achieving a caries free healthy tooth as the bonding substrate, air abrading the underlying composite, de-activating of matrix metallo-proteinases, immediate dentine sealing and deep margin elevation whenever required. The combination of each protocol with due care and caution helps to attain a predictable long-standing restoration [1]. There are no surveys and studies that have been carried out in Tripoli to assess the level of awareness and knowledge of specialist and general dentists toward biomimetic dentistry, therefore a questionnaire was used in this survey to assess knowledge and attitudes toward biomimetic dental materials and techniques among general dentists, and specialists in Tripoli, Libya.

METHODS

The questionnaire was designed to assess the knowledge and opinion toward biomimetic dentistry among Libyan dentists in Tripoli, adapted from pretested questionnaire that has been applied in similar study of Jaju and Nasim (2020) which has been conducted in India [7].

This study was conducted in Tripoli in October 2023, the questionnaire was consisted of 21 yes, no questions and part of it was distributed electronically and the remainder was distributed personally by the authors.

A pilot test was conducted over sample (n=20) of target group to ensure the clarity of the questions, feedback obtained during this pilot phase was used to refine and enhance the questionnaire. A structured questionnaire was developed to address key aspects of biomimetic dentistry knowledge and awareness. Demographic details were obtained including educational qualifications and years of experience. In addition to demographic details, the questionnaire included sections on: General awareness and

understanding of biomimetic dentistry principles. And Familiarity with biomimetic restorative materials and techniques. The data were sorted, checked for completeness and consistency, summarized, tabulated, and statistically analyzed. Statistical analysis was performed using SPSS IBM V.22.

RESULTS

The results of this study showed that response rate was 96% (out of 100 questionnaires distributed 96 were filled by Libyan dentists). 65.6% were general dentists, holding a bachelor's degree, and 34.4% were specialists, were master degree and PhD degree holders (specialists). Table 1 Shows a detailed overview of the demographic characteristics of the respondents. Regarding years of experience. 37.5% reported having more than 10 years of experience in the dental field, while 37.5% having 1-5 years of experience, and 25% having 6-10 years of experience.

Table 1: Demographic Profile of Study Participants.

Characteristic		Frequency (n)	Percentage (%)
Qualifications	Specialist	33	34.4
	General dentist	63	65.6
Years of experience	1-5 years	36	37.5
	6-10 years	24	25.0

The second segment of the survey aimed to evaluate participants' knowledge and attitude regarding biomimetic dentistry. Table 2 Shows that the highest level of awareness has been found among specialists (90.9%) and the lowest level was among general dentists, with 76.2% being aware of biomimetic materials. From the table we noted that the percentage of awareness tends to increase with increase in years of experience. Also, we noted that the specialists prefer to use biomimetic materials more than general dentists.

Table 2: Awareness, knowledge and attitude of specialists and general dentists toward biomimetic dentistry.

Question	Response	Years of experience			Specialist	General dentist
		1-5	6-10	>10		
Are you aware of biomimetic materials used in conservative dentistry and endodontics?	Yes	72.2%	83.3%	88.9%	90.9%	76.2%
	No	27.8%	16.7%	11.1%	9.1%	23.8%
Do you prefer to use biomimetic approach when treating your patient?	Yes	77.8%	79.2%	94.4%	93.9%	79.4
	No	22.2%	20.8%	5.6%	6.1%	20.6
Biomimetic materials are materials that simulate tooth material with additional bioactive properties being present.	Yes	88.9%	87.5%	94.4%	84.8%	85.7
	No	11.1%	12.5%	5.6%	15.2	14.3
Does the biomimetic dentistry use recent adhesive techniques to bond dental materials to tooth structure?	Yes	80.6%	91.7%	94.4%	93.9	85.7
	No	19.4%	8.3%	5.6%	6.1	14.3
Biomimetic materials include: mineral trioxide aggregate, calcium hydroxide, glass ionomer and biodentin.	Yes	77.8%	83.3%	94.4%	100.0	77.8
	No	22.2%	16.7%	5.6%	000.0	22.2
Do you prefer to use mineral trioxide aggregate instead of calcium hydroxide as a pulp capping agent?	Yes	69.4%	75.0%	69.4%	75.8	68.3
	No	30.6%	25.0%	30.6%	24.2	31.7
Do you use endosequence material in case of perforation?	Yes	52.8	75.0	58.3	51.5	65.1
	No	47.2	25.0	41.7	48.5	34.9
Do you frequently use bioceramic sealer in root canal treatment?	Yes	61.1	70.8	55.6	57.6	63.5
	No	38.9	29.2	44.4	42.4	36.5
Are you using bioceramic coated gutta-percha in root canal treatment?	Yes	52.8	75.0	52.8	57.6	58.7
	No	47.2	25.0	47.2	42.4	41.3

The study revealed that high percentages of dentists have a knowledge that biomimetic materials are materials simulate tooth material with additional bioactive properties, also they agree that biomimetic dentistry use recent adhesive techniques to bond to tooth structure.

Also, this table shows the preferences of dentists for using mineral trioxide aggregate (MTA) instead of calcium hydroxide as a pulp capping agent and the use of endo-sequence material in case of perforation.

There is reduced level among dentists of using of bioceramic endodontic sealer and bioceramic coated gutta-percha.

Table 3 Provides valuable information about the level of practicing of biomimetic techniques among specialists and general dentists. The results presented in the data showed that the majority of practitioners general dentists and specialists agreed that the use magnification is essential for biomimetic approach in treating deep carious lesion (ranging from 75.8% specialists to 79.4% general dentists).

Table 3: Practice of biomimetic techniques among specialists and general dentists.

Question	Response	Years of experience			Specialist	General dentist
		1-5	6-10	>10		
Is a magnification essential for biomimetic approach in treating deep carious lesion?	Yes	80.6	83.3	72.2	75.8	79.4
	No	19.4	16.7	27.8	24.2	20.6
Are you using deep marginal elevation technique in management of deep carious lesion?	Yes	80.6	83.3	69.4	75.8	77.8
	No	19.4	16.7	30.6	24.2	22.2
Do you follow stress- reducing approach in treating of deep carious lesion?	Yes	69.4	66.7	72.2	66.7	71.4
	No	30.6	33.3	27.8	33.3	28.6
Do you use immediate dentin sealing during management of deep carious lesion?	Yes	52.8	75.0	77.8	75.8	63.5
	No	47.2	25.0	22.2	24.2	36.5
Do you use chlorhexidine to toilet the prepared cavity before applying composite resin restorative material?	Yes	30.6	33.3	44.4	39.4	34.9
	No	69.4	66.7	55.6	60.6	65.1
Do you prefer to use fiber- reinforced composite in floor of the deep cavity instead of flowable composite?	Yes	69.4	54.2	47.2	48.5	61.9
	No	30.6	45.8	52.8	51.5	38.1
Do you think the limiting factors for using biomimetic materials and techniques instead of conventional approach for management of carious lesion are: Unavailability of the materials and cost?	Yes	77.8	95.8	91.7	100.0	81.0
	No	22.2	4.2	8.3	000.0	19.0
Do you think the limiting factors for using biomimetic materials and techniques instead of conventional approach for management of carious lesion is lack of knowledge and information about biomimetic dentistry?	Yes	77.8	70.8	86.1	87.9	74.6
	No	22.2	29.2	13.9	12.1	25.4

Regarding use of deep marginal elevation technique about 75.8% of specialists use this technique in the management of deep carious lesions and about 77.8% of general dentists use this technique.

Additionally, a significant proportion of practitioners follow a stress-reducing approach (69.4%) and use immediate dentin sealing (75.8 specialists) and (63.5

general dentists) during the management of deep carious lesions.

Interestingly, the use of chlorhexidine to toilet the prepared cavity before applying composite resin restorative material was reported by a relatively smaller proportion of practitioners. Similarly, the use of fiber-reinforced composite in the floor of the deep cavity instead of flowable composite was reported by

a relatively smaller proportion of practitioners. The data also suggests that the years of experience of the practitioners do not significantly influence their adoption of biomimetic approaches. Finally, the data suggests that the perceived limiting factors for using biomimetic materials and techniques instead of conventional approaches for carious lesion management are the unavailability of the materials and cost (ranging from 81.0% to 100.0%). Interestingly, lack of knowledge and information about biomimetic dentistry was also reported as a limiting factor by a significant proportion of practitioners (ranging from 70.8% to 87.9%).

DISCUSSION

Biomimetic dentistry is a discipline that focuses on advanced adhesive techniques to restore teeth by mimicking natural tooth structure. This approach conserving as much natural tooth structure as possible, promoting the longevity of the dentition [9].

This survey was conducted on the knowledge, attitude, and practice of biomimetic dentistry among general dentists and specialists in Tripoli, Libya. This study was done to yield valuable information on the current level of understanding and application of biomimetic in their daily practice. The result of this study showed that higher percentage of dentists especially those with higher years of practice prefer to treat their patients using biomimetic approach (93.9% with >10 years of experience). This preference was found to be higher among specialists compared to general dentists (94.4% vs. 79.4%) The result of this study showed that high percentage of both specialist and non-specialist dentists prefer that biomimetic materials should simulate tooth material with additional bioactive properties.

The survey noted that a large proportion of both specialist and non-specialist dentists are aware that biomimetic materials simulate tooth material with additional bioactive properties. These observations align with findings from a previous survey conducted in India by Jaju and Nasim (2020) which indicates that an exceedingly high percentage of the

participants had a sound knowledge about biomimetic materials and all the participants are ready to use biomimetic materials in their regular practices [7]. However, another study conducted in 2022 by Dr. Mohammed Hussain Dafer Al Wadei, Assistant Professor in the Department of Restorative Dental Science at the College of Dentistry, King Khalid University, Abha, Saudi Arabia, found contrasting results. He discovered that just a third of respondents actually used biomimetic materials in their day-to-day work. His study showed that even endodontists were familiar with and hopeful about using biomimetic materials, they also indicated a need for further education on the topic [8].

The study reported that 85.7% of specialists agree that biomimetic dentistry uses recent adhesive techniques to bond dental materials to tooth structure. The core concept of biomimetic dentistry is to create a "monoblock" between the restorative material and the tooth, allowing functional stress to be dissipated through the tooth structure, restoring both mechanical and biological function optimally [1].

The results showed dentists' preferences for using mineral trioxide aggregate (MTA) over calcium hydroxide as a pulp capping agent One notable example is the preference for MTA due to its superior clinical performance in maintaining long-term tooth vitality and its less toxic pulpal tissue response compared to calcium hydroxide [10].

Despite the advantages of bioceramic-based sealers and bioceramic-coated gutta-percha, their utilization remains underutilized among Libyan dentists. Bioceramic sealers offer potent antimicrobial properties, biocompatibility, and ease of handling, making them an attractive alternative to traditional sealers. Bioceramic-coated gutta-percha cones expand in a wet environment to create a fluid-tight seal, strengthening the root structure and reducing stress within the tooth [11].

From this study we found that there is a reduced level of use of EndoSequence material in cases of perforation among Libyan dentists, despite EndoSequence being a novel bioceramic root repair

material that contains calcium silicates, calcium phosphates monobasic, zirconium oxide, tantalum oxide, and other filler agents [12].

The survey also highlights variations in the use of specific biomimetic techniques among dentists based on their years of experience and qualifications, In the third part of this questionnaire which is about practices of biomimetic techniques. The majority of respondents (76.9%) affirmed the indispensability of magnification for a biomimetic approach in treating deep carious lesions. This inclination reflects an understanding among practitioners of the need for enhanced precision and detailed visualization in biomimetic practices [13].

The high percentage (77.8%) of practitioners utilizing the deep marginal elevation technique in the management of deep carious lesions suggests a notable incorporation of advanced techniques to preserve tooth structure. Subgingival margins present a challenge due to limited access and issues like rubber dam slippage, saliva, and crevice fluid leakage. Traditional approaches involve orthodontic extrusion or surgical exposure to access subgingival margins, but these can lead to attachment loss, dentin hypersensitivity, and esthetic compromises. An alternative, conservative approach is "deep margin elevation" [14].

a significant proportion of practitioners follow a stress-reducing approach (ranging from 66.7% to 72.2%) This reflects an awareness among practitioners of the significance of minimizing stress during restorative procedures, contributing to the preservation of tooth vitality—a key objective of biomimetic dentistry. The biomimetic restorative protocols that dental clinicians should follow and are divided into two main groups: a) stress-reducing and b) bond-maximizing protocols. Stress reducing protocols include: 1) the use of indirect or semidirect restorations for the occlusal and interproximal enamel replacements, 2) the reduction of the increment thickness of the composites (< 2 mm) in dentin surfaces, 3) the incorporation of reinforcing fibers in composite restorations, 4) the selection of slow start or

pulse-activated polymerization techniques,5) the utilization of dentin replacing composites with low shrinkage (< 3%) and range of modulus of elasticity between 12-20 GPa, 6) the use of dual cure composite materials when restoring pulp chambers in non-vital teeth, 7) the removal of dentin cracks within 2 mm of the dentino-enamel junction, 8) the limitation of onlay cusps to thinner than 2 mm and 9) the verticalization of occlusal forces by restoring anterior guidance with bonded composite to the lingual surface of maxillary cuspids and the facial surfaces of mandibular cuspids [9].

The use of fiber-reinforced composite in the floor of the deep cavity instead of flowable composite was reported by a relatively smaller proportion of Libyan practitioners (ranging from 47.2% to 69.4%). Fiber-reinforced composite restorations are resin-based restorations that contain fibers to improve the physical properties of the composites. The fibers increase the structural properties of the material by acting as crack stoppers. The resin matrix protects the fibers and stabilizes their geometry to provide optimum reinforcement Fiber [15].

One of the most important techniques of bond-maximizing protocols is the immediate dentin sealing, the widespread adoption of immediate dentin sealing during the management of deep carious lesions among Libyan dentists (ranging from 52.8% to 77.8%) signifies a recognition of the benefits of sealing dentin immediately after preparation. This practice aligns with biomimetic principles, aiming to enhance the longevity and performance of restorations by protecting dentin from bacterial ingress and fluid penetration. Immediate dentin sealing and resin coating yielding better bond strengths. Immediate dentin sealing and resin coating addresses the fundamental problem in adhesive dentistry where the polymerization shrinkage stress exceeds the early dentin bond strengths leading to delamination of the adhesive and the composite, setting the stage for microleakage. To address this concern, the newly bonded dentin surface must have time to "mature"

before being loaded by the shrinkage stresses of the incoming composite resin restorative material [16].

However, it is noteworthy that there is a deficiency in the application of certain biomimetic techniques, for instance, the utilization of chlorhexidine to cleanse the cavity before the placement of composite to enhance adhesion. This will deactivate matrix metalloproteinases. This prevents 25% to 30% of bond strength from being degraded. Deactivation can be achieved by using a 30 second treatment with 2% chlorhexidine [12].

The last two questions in this survey were about the limiting factor for using biomimetic materials and techniques instead of conventional approach for management of carious lesion, the results showed that high percentage of participant (specialists and general dentists) agreed that : Unavailability of the materials and cost in addition to the lack of knowledge and information about biomimetic dentistry are the limiting factors for adoption of biomimetic dentistry by the Libyan dentists in Tripoli.

CONCLUSION

The present study concludes that the lack of knowledge, unavailability and high cost constitute major obstacles to the use of biomimetic materials when compared to conventional methods. Nonetheless, awareness is growing and the attitudes are overwhelmingly positive with respect to biomimetic dental materials and methods. This seems particularly true in the case of more experienced, highly qualified clinicians. To fill these gaps, seamless education on biomimetic methodologies should be implemented into the curriculum of undergraduate dental studies. In addition, providing particular postgraduate courses about biomimetic dentistry would boost dentist ability and knowledge to use these recent techniques in their regular practice.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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