Keywords
Preventive dentistry; Restorative dentistry; Bioactive materials; Minimally invasive dentistry; Digital dentistry; Artificial intelligence

Authors
[1]*Dr. R. Venkatasubramanian, Professor & HOD, Department of Pediatric and Preventive Dentistry, Specialization in Pedodontist, Dayananada Sagar College of Dental Sciences, Bangalore-560011, Email Id: venkatasubramanian@dscds.edu.in , Orcid Id:0009-0009-6206-2630

[2]Dr Mahesh Kumar T S, Professor, Department of Oral Medicine and Radiology, Specialization in Oral Medicine and Radiology, 14 Rajarajeswari Dental College and Hospital, Ramohalli cross Kumbalagodu Bangalore 560074, Email Id: maheshtalkad.mk@gmail.com , Orcid Id: 0000-0003-4382-4889

[3]Dr Sagarika Rupainwar, Assistant Professor, Department of Forensic Sciences, Specialisation in Forensic Odontology, School of Allied & Health Sciences, CGC University, Mohali-140307, Email Id: sagarika.rupainwar@gmail.com , Orcid Id: 0009-0002-7729-6121

[4]Dr. Moupali Roy, Assistant Professor, Department of Electronics and Communication Engineering, Specialization in Control System, Narula Institute of Technology, Kolkata, West Bengal, India, Email Id: moupali.roy@nit.ac.in , Orcid Id: 0000-0002-1745-459X

[5]Jyotiprava Swain, Department of Prosthodontics, Specialization in Prosthodontics, Kalinga institute of dental sciences, Kalinga Institute of Industrial Technology- Deemed to be University, KIMS campus, Bhubaneswar-751024, Email Id: jyotipravas985@gmail.com , Orcid Id: 0009-0002-2053-1020

[6]Harmohan Singh Yadav, Associate Professor, School of Agriculture, Department of Soil Science and Agricultural Chemistry, Specialization in Soil fertility, Lovely Professional University Jalandhar Punjab 144411, Email Id: drhms.srcm@gmail.com , Orcid Id: 0000-0001-5942-2708 .

Received:26-06-2026
Revised:27-07-2026
Accepted:05-08-2026
Doi:10.1922/ejprd.v34i7s.1684

Advances in Preventive and Restorative Dentistry Innovations in Materials, Techniques, and Patient Centered Care

Abstract
Preventive and restorative dentistry has radically changed its conventional, invasive, treatment modalities into minimal invasive, patient-centered and technologically enhanced modalities. The current study is concerned with the recent developments in preventive measures, restorative materials, techniques, and digital technologies and their role in enhancing oral health. The current preventive dentistry is risk-based and tailored, with the application of new fluoride technology, bioactive compounds, manipulation of microbiomes, and early detection of disease as the means to improve disease prevention and management. Restorative dentistry has also been enhanced by the development of new materials, including composite resin, bioactive and biomimetic materials, glass ionomer cements and smart materials with antibacterial and remineralizing properties. Other new technologies that have enhanced accuracy of the treatment, speed and patient comfort are minimally invasive dentistry, atraumatic restorative treatment, laser technologies, computer aided design and manufacturing (CAD/CAM), and 3D printing. Diagnostic, treatment planning and individual care using data analytics, digital smile design and teledentistry have been revolutionised using digital dentistry and artificial intelligence. Moreover, patient satisfaction and compliance has been optimised through patient-centred strategies that put into consideration behavioural, psychological, and social considerations. However, the barriers still exist in the form of cost, accessibility, material durability and ethics. The future is regenerative dentistry, nanotechnology and precision dentistry. In conclusion, the use of new materials, technologies, and patient-centered solutions is a disruptive approach of the modern dentistry that provides better clinical outcomes and long-term oral health solutions.

INTRODUCTION

Preventive and restorative dentistry has transformed over the past decades to become a more conservative approach, rather than the historically invasive, repair-oriented approach. This change reflects the acceptance of oral diseases as dynamic, multifactorial processes, which require early identification and continuous control, as opposed to reactive treatment. In particular, dental caries remains one of the most prevalent chronic conditions in the world, affecting billions of individuals and is a significant health burden. According to epidemiological research, the global dental caries burden without treatment has not decreased between 1990 and 2019 with large regional and socioeconomic differences [1]. This also points to the necessity of new strategies, which would be based on preventive strategies, early diagnosis and minimal intervention.

Minimal intervention dentistry (MID) has emerged as a fundamental principle of modern dentistry. MID aims at maintaining healthy dental tissue, early carious lesion, and preventive and non-invasive interventions where available. Methods such as atraumatic restorative treatment (ART) are the best illustrations of this method as they enable effective caries management with minimum tooth loss and without the aid of complex machinery [2]. Furthermore, the recent clinical practice recommendations suggest selective interventions, which are dependent on the activity of the lesion and the risk factors of the patient, instead of treating all lesions proactively, thereby enabling more personalised and evidence-based dentistry [3].

Sustainability in dental practice has become increasingly a focus, alongside the shift towards minimally invasive dentistry. Sustainable dentistry is meant to reduce the environmental impact of dental materials, practices and waste without affecting the health of the patient. This includes the application of biomaterials that are environmentally friendly, reduction in the utilisation of harmful chemicals and effective utilisation of resources in practice. Sustainable dentistry development is one of the global trends of environmentally sustainable health care and highlights the necessity of innovation that takes into account the clinical and environmental effects [4]. The new trends in biomaterials also contribute to this goal, as they provide biocompatible, stable, and environmentally friendly solutions [5].

The other significant aspect of modern dentistry is the emergence of the new knowledge about the importance of the oral microbiome in disease and health. The contact between the microbes and the host plays a crucial role in the pathogenesis of caries and periodontal diseases. Recent studies have investigated what biomolecular therapies and natural products can achieve to regulate the oral microbiome, which presents new opportunities in preventive strategies [6,7]. These interventions are aimed at not only inhibiting pathogenic microorganisms but also restoring the natural microbial balance, which enhances oral health in the long run [7].

The biological sciences have also improved the knowledge of the systemic factors that affect oral health. The risk and severity of caries have been linked to indicatively endocrine and other systemic pathologies and this has provided the need to adopt an integrated approach to health [8]. On the same note, the advancement of implant dentistry, and tissue engineering has enhanced the success of the restorative procedure with enhanced osseointegration and prosthesis longevity [9]. This study demonstrates the increased adoption of preventive, restorative and regenerative approach in dentistry.

However, research innovations still encounter a lot of translation barriers in regard to their application in clinical practice. Access to care, education of professionals and financial problems are also the factors that lead to the implementation of new technologies and treatment. And the speed of development of dental materials and methods must be continually reviewed through well-conducted research and systematic reviews to ensure safety and efficacy [8].

To sum up, the materials, biology and patient-centered dentistry inventions are bringing a revolution to the field of preventive and restorative dentistry. Minimal intervention combined with sustainability and innovative technologies have a tremendous potential to improve oral health and decrease health disparities across the globe. This review talks about such developments in detail, their clinical implications and the future of dentistry.

2. ADVANCES IN PREVENTIVE DENTISTRY

2.1 Modern Concepts of Prevention: Risk-Based and Personalized Dentistry

The development of preventive dentistry as one size fits all model with a focus on the elimination of plaque and the utilisation of fluoride to a more sophisticated, risk-focused and individualised model has been a lengthy journey. The existing preventive strategies are aimed at the early diagnosis, specific therapy and manipulation of risk factors to reverse the disease mechanisms. Current clinical practice guidelines recommend the use of caries risk assessment, lesion activity and patient-specific factors (such as diet, oral hygiene and systemic health) to guide preventive interventions [10,11]. This transition to personalised dentistry mirrors those in other areas of healthcare, as precision medicine seeks to improve patient outcomes through tailored care. Figure 1 shows the evolution from conventional restorative to preventive, minimally invasive and patient-centred dentistry

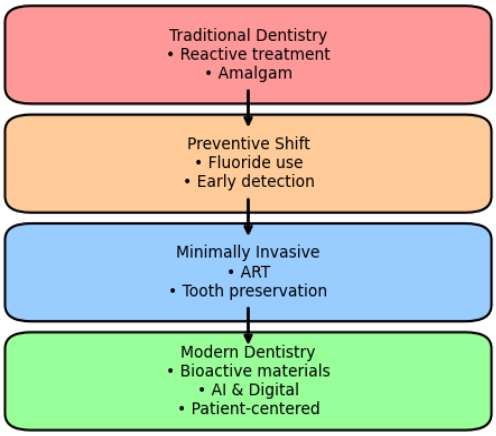

Figure 1. Evolution of Preventive and Restorative Dentistry

2.2 Fluoride Advancements and Preventive Agents

Fluoride therapy has come to be among the most significant advances in preventive dentistry. Fluoride remains the cornerstone of the caries-prevention measures due to its demonstrated ability to induce enamel remineralization and inhibit demineralization. Over the past years, its application has changed the traditional toothpastes and mouth rinses to high-concentration varnishes and new delivery methods. As an illustration, fluoride varnishes have proven to be very effective in reducing the prevalence of caries in different age groups and caries-risk groups [12]. In addition, new technologies such as intra-oral fluoride devices that release fluoride over an extended period of time, improve the acid resistance of the enamel to provide all-time protection against caries [13]. The benefits of combining fluoride with calcium pre-treatments to boost enamel reactivity and remineralization capacity have also been investigated [14]. The history of preventive measures, between the old and the new, highlights the changes in the approach to preventive care towards individualised, risk-based preventive care, which is enabled by bioactive materials and diagnostic devices Table 1.

Table 1: Comparison of Traditional vs Modern Preventive Approaches

Aspect	Traditional Prevention	Modern Preventive Dentistry	References
Approach	Generalized, one-size-fits-all	Risk-based, personalized care	[10]
Focus	Plaque removal and symptom control	Disease prevention, remineralization, and risk control	[11]
Fluoride Use	Toothpaste, mouth rinses	Varnishes, slow-release devices, enhanced delivery systems	[12]
Materials	Passive preventive agents	Bioactive and biomimetic materials (e.g., hydroxyapatite)	[15]
Microbiome Approach	Elimination of pathogens	Ecological balance and microbiome modulation	[16]
Diagnostics	Visual examination and radiographs	Digital diagnostics, salivary biomarkers, early detection tools	[17]
Patient Role	Passive recipient of care	Active participation and self-management	[10]
Effectiveness	Reactive and treatment-oriented	Preventive, predictive, and minimally invasive	[11]

2.3 Bioactive and Biomimetic Preventive Materials

The other important phenomenon, as well as fluoride, is the production of bioactive and biomimetic preventive materials. The products are supposed to replicate the natural mineralisation of teeth, and to repair enamel and dentin. An example of these biomimetic behaviours is seen in the case of zinc-substituted hydroxyapatite that has been shown to induce remineralisation and possesses antibacterial properties and therefore, achieves preventive and therapeutic outcome [15]. Similarly, new antimicrobial peptide-polymer conjugates have been created to kill pathogenic bacteria selectively without affect on the beneficial microbiota [18]. These interventions are a move towards not only antimicrobial but rather restoring and fostering ecological balance in the mouth.

2.4 Role of Oral Microbiome in Prevention

Oral microbiome and its impact on caries have emerged as a significant research topic. Caries is now considered to be a dysbiotic disease, and is brought about by a change in the microbiome of the mouth, and not the pathogenic microbes. The most recent research on the microbiome has provided more detail on the intricate connection between host and microbial factors and the necessity to possess a healthy and varied microbiota in order to achieve optimal oral health [16]. The interventions have shifted more towards manipulating the microbiome by using probiotics, prebiotics, and certain antimicrobials. They will help to maintain microbial balance to a health related state thereby preventing disease.

2.5 Advances in Diagnostics and Early Detection

Simultaneously, the early detection and prevention of dental caries has also improved. The new technologies are being combined with the old diagnostic methods such as the visual-tactile and radiographic examination in order to detect the early and non-cavitated lesions. Techniques such as laser fluorescence, digital radiography and optical coherence tomography are more sensitive and specific to detect early lesions and allow early intervention and improved outcome of the treatment [17]. Another rapidly gaining popularity method of assessing the risk of caries is salivary diagnostics, which involves measuring biomarkers of bacteria activity, host response and tooth demineralization. Epidemiological studies that indicate changes in the prevalence and risk factors of caries population also indicate the need to detect early [19].

Another factor that allows these materials to increase their ability to facilitate remineralization and inhibit bacteria growth is the bioactive agents included in these materials. They can be integrated with risk-based preventive interventions to offer a holistic approach to managing caries, which considers not only the structural but also the biological determinants [17].

3. INNOVATIONS IN RESTORATIVE DENTAL MATERIALS

The development of dental restorative materials during the last decades has not only created functional materials, but also highly advanced biomaterials, which are able to mimic natural tooth structure, stimulate regeneration and prolong life. These changes are necessary because minimal invasive procedures are required, better aesthetics and clinical durability. The restorative materials of the present day can not only restore the structure of the tooth but also help to prevent secondary caries and keep the health [20].

3.1 Evolution from Amalgam to Composite Resins

Traditionally, dental amalgam has been used to restore the back teeth since it is strong, simple to implement and inexpensive. Nevertheless, it has lost popularity due to the aesthetics, mercury content and environmental concerns. However, composite resins are being used now because they have an improved appearance and bonding ability. The new composite materials such as filler particles and resin matrix have greatly augmented their strength, wear resistance and durability [21]. The contemporary composites have also improved polymerization, little shrinkage and improved colour stability that enable them to be applied in anterior and posterior areas.

3.2 Bulk-Fill Composites and Nanocomposites

Composite technology has also innovated in the form of bulk-fill composite and nanocomposites that have addressed some of the shortfalls of the traditional composite. Bulk-fill composites can be deposited in bigger steps (4-5 mm) that minimizes the time of the procedure and is not as technique sensitive without influencing the depth of cure and mechanical properties. Nanocomposites on the other hand make use of nanometer fillers in the effort of obtaining a superior polishability, esthetics and wearability. They are powerful and esthetic in well balanced matrix and are thus, versatile materials which could be utilized in wide range of clinical applications [21]. Their superior physical properties lead to better clinical performance and patient satisfaction.

3.3 Bioactive and Biomimetic Materials

Composites have been developed into bulk-fill composites and nanocomposites, which are solutions to some of the deficiencies of traditional composites. Bulk-fill composites permit a larger placement thickness (4-5 mm) and lessen the placement time and are not as technique sensitive and still provide sufficient depth of cure and physical characteristics. Instead, nanocomposites have fillers in the nanometer range to enhance polishability, esthetics and wear resistance. They possess strengths and esthetics on a balanced matrix, and can be applied to a wide range of applications [22]. They have improved physical properties and clinical success and higher patient satisfaction.

3.4 Glass Ionomer Cements and Resin-Modified GICs

Glass ionomer cements (GICs) are known to release fluoride and to bond to dentin. The new trends have made them stronger and more versatile. Bioactive Glass ionomer cement e.g. has been demonstrated to possess better remineralization and antibacterial properties and can be utilized in high risk patients with dental decay [23]. The advantages of resin-modified glass ionomer cements (RMGICs) include those of the conventional GICs, but with increased strength and aesthetics. They have enhanced handling qualities, wear and resistance and moisture. They continue to play a critical role in caries inhibition especially secondary caries in children and the elderly due to their involvement in the release of fluoride.

3.5 Smart Materials: Self-Healing and Antibacterial Properties

The latest technology in restorative dentistry is intelligent materials. These materials are reactive to their environment, pH or mechanical forces to improve their properties. An example is self-healing material which can be used to repair microcracks in the restoration, increasing its life. And antibacterial agents contain the materials that prevent the development of biofilms of bacteria and consequently prevent the development of secondary caries.

New materials, including amyloid-based hydrogels, have been demonstrated to possess remineralizing and antibacterial properties, which combine restorative and preventive properties [24]. These developments show the potential of integrating therapeutic functionality into restorative materials, and they become an active partner in combating dental diseases.

3.6 Advances in Adhesive Systems and Secondary Caries Prevention

The dental adhesives play an important role in the sustainability of restorative therapies since they enable bonding to the tooth. The recent trends have been to strengthen the bond, decrease the sensitivity of technique, and increase the durability. As an example, bioactive adhesives can release ions that facilitate the remineralization, and are antibacterial to minimize the possibility of secondary caries [24,25].

Secondary caries is one of the major reasons of the failure of restorations. Studies have indicated that the factors that need to be controlled to reduce this risk are the marginal integrity, material characteristics and patient factors [26]. Incorporating remineralizing and antimicrobial agents into adhesives is an approach that may enhance longevity.

3.7 Biocompatibility and Clinical Considerations

Although the restorative materials have been improved in terms of their properties, biocompatibility is a factor to be considered. They should be able to co-exist with the oral tissues and not cause adverse reaction. Recent research has raised questions over the cytotoxicity and long term biocompatibility of some restorative materials and there is a need to carry out extensive tests and clinical validation [27].Figure 2 demonstrates the types of contemporary restorative materials such as composite resins, glass ionomer cements, bioactive and biomimetic materials and smart materials.

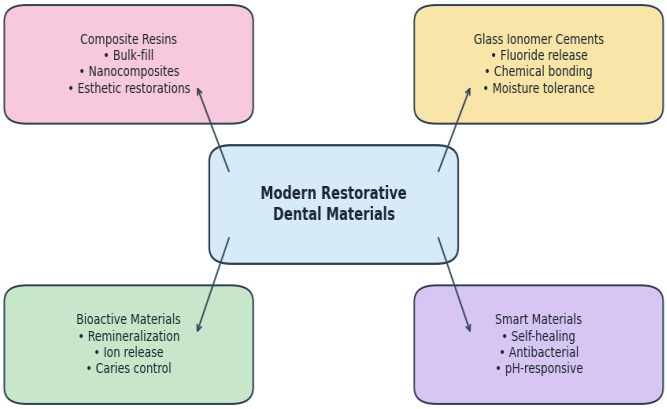

Figure 2: Classification and Properties of Modern Restorative Materials

4. EMERGING RESTORATIVE TECHNIQUES AND TECHNOLOGIES

Restorative dentistry developments are not merely in the materials but far beyond that to new methods of doing things and new technologies that make it more accurate, effective and better patient results. The restorative procedures have been made more predictable, conservative and patient-centered by minimal invasive and digital and automated systems.

4.1 Minimally Invasive Dentistry (MID) Principles

Minimally invasive dentistry (MID) is another important concept of the present-day restorative practice. It concentrates on the early diagnosis, risk assessment, and preservation of healthy tooth structure through the use of conservative interventions. MID does not focus on mass ablation of carious tissues, but rather selective ablation of caries, regeneration of the caries ablated, and the long-term control of the disease. This not only prolongs the life of the teeth, but also reduces the pain and costs incurred by the patient and cost of treatment [28]. MID principles are rather similar to preventive dentistry and help to shift to the sphere of surgical treatment as well as biological management of dental caries.

4.2 Atraumatic Restorative Treatment (ART)

Atraumatic restorative treatment (ART) is one of the primary applications of MID and is particularly helpful in community and low-resource settings. ART involves evisceration of the decayed tissue using hand tools and filling the tooth using adhesive materials such as glass ionomer cement. The procedure does not involve rotary tools and local anesthesia in most cases hence, it is less painful and accessible to the patients [29]. ART has been widely recognized to be effective in managing dental caries and in maintaining tooth structure and alleviating anxiety in patients [2]. It is a significant part of oral health strategies in the world because of its simplicity and cost-effectiveness.

4.3 Laser-Assisted Dentistry

Laser technology has emerged as an instrument that is non-invasive and highly precise in restorative dentistry. The use of lasers can be used in caries, cavity preparation, soft tissue management and disinfection of the operative field. The advantages of laser-assisted procedures over the traditional rotary instruments are numerous, including reduced pain, reduced vibrations, reduced anesthesia and increased comfort to the patient. In addition, lasers are more accurate, and this implies that one can selectively ablate diseased tissues without causing harm to normal structures. Clinical studies have demonstrated lasers to be an effective minimally invasive substitute to a number of dental procedures [30]. Although such advantages are present, equipment cost and the necessity of specific training are still the obstacles to widespread adoption.

4.4 CAD/CAM Restorations and Digital Dentistry

The computer aided design and computer aided manufacturing (CAD/CAM) technologies have revolutionized the restorative dentistry in that it is now possible to develop highly precise and esthetic restorations. The CAD/CAM systems allow clinicians to plan and fabricate crowns, inlays, onlays and veneers with high precision and efficiency. Microstructural features of CAD/CAM material have also been studied and they are found to be more robust, durable and attractive [28].

Zirconia-based and lithium disilicate restorations are widely used in CAD/CAM systems and have demonstrated great marginal fit and long-term clinical outcomes, which have led to their popularity in restorative practice [31]. The CAD/CAM technology associated with the digital workflow reduces the dependence on the laboratory, reduces the time of treatment, and enhances

the reproducibility. In addition, digital dentistry improves the communication between clinicians and dental technicians, which improves treatment planning and results.

4.5 3D Printing in Restorative Dentistry

One of the significant innovations in restorative and prosthetic dentistry is additive manufacturing or three-dimensional (3D) printing. The technology enables one to make dental models, surgical guides, temporary restorations, and even permanent prostheses in high precision and personalization. A reduction in the amount of waste of materials, faster manufacturing, and the potential to create complex geometries are some of the advantages of 3D printing, which would be difficult to get using a conventional approach [32].

The mechanical properties and bond strength of 3D-printed dental materials have also been explored in recent studies and have the potential to be used in clinical applications [33]. As the technology continues to become better, improved material properties and printing accuracy should be able to enable its use in restorative dentistry to an even greater degree.

4.6 Digital Impressions and Workflow Integration

Most clinical facilities have replaced traditional ways of impression with the digital impression systems, which are more precise, comfortable to the patients and efficient. Images of the dental structures are formed in the detailed three-dimensional shape in intraoral scanners, and impression materials are not required, which can be uncomfortable and distortive. These computer impressions can be readily integrated into CAD/CAM processes and enable restorations to be made in a short duration [28].

The entire process of restorative practice including diagnosis and treatment plan, fabrication and placement of restorations has been made easy by the introduction of digital technologies to clinical practice. This is an electronic workflow that enhances precision, reduces human error, and the overall treatment outcomes. Furthermore, it allows a better interaction with patients as the treatment plan and expected results could be visualized. New restorative technologies are becoming much more beneficial compared to the old methods based on accuracy, efficiency and patient comfort as tabulated in Table 2.

Table 2: Comparison of Conventional vs Digital/Advanced Restorative Techniques

Aspect	Conventional Techniques	Digital/Advanced Techniques	References
Approach	Invasive, removal-focused	Minimally invasive, preservation-focused	[2]
Instruments	Rotary tools	Lasers, digital tools	[30]
Impression Method	Physical impressions	Digital intraoral scanning	[34]
Fabrication	Laboratory-dependent	CAD/CAM and 3D printing	[32]
Accuracy	Variable	High precision and reproducibility	[31]
Time Efficiency	Multiple visits	Reduced chairside time, single-visit options	[28]
Patient Comfort	Moderate discomfort	Improved comfort and reduced anxiety	[30]
Material Innovation	Limited	Advanced ceramics, printed materials	[33]

5. PATIENT-CENTERED CARE IN PREVENTIVE AND RESTORATIVE DENTISTRY

The notion of patient-centered care has become one of the values of the modern dental practice due to the shift in the paradigm of decision-making on behalf of the clinician to a more integrated, more personalized one. It is a patient-centered model, which emphasizes the needs, preferences, values, and expectations of patients and integrates clinical knowledge and evidence-based practices. Patient-centered care is particularly important in preventive and restorative dentistry where the effectiveness of treatment does not only depend on the clinical outcomes but also patient satisfaction, adherence, and behavioral changes.

5.1 Concept of Patient-Centered Dentistry

Patient-centered dentistry is a method that is concerned with delivering care that is responsive and respectful of the needs, preferences and the values of the individual patient. It combines clinical decision-making and patient participation, and makes the treatment plans scientifically grounded and personally anticipated. Evidence-based decision-making is an important part of this process because clinicians need to consider evidence in the research and patient-related variables to get the most successful outcomes [35].

In addition, decision-making process in the field of dentistry is becoming known as a collaborative process and the clinician and the patient have a role in deciding which treatment should be provided. This cooperative method will generate a greater degree of trust among patients, greater acceptance of treatment and eventually, clinical outcome [36].

5.2 Behavioral and Psychological Considerations

Psychological and behavioral factors mostly determine oral health and patient involvement. Dental anxiety, fear and negative past experiences can be examples of prejudice that impedes care seeking and care giving. These aspects should be understood to establish the conducive clinical environment and to design the effective communication strategy.

The socioeconomic factors also play a major role in determining oral health behavior and access to care too. It has been shown that patients who have low socioeconomic status tend to have dental disease and limited access to preventive care, which is why patient-centered care must take health disparities into consideration [37]. These factors will enable clinicians to develop interventions that can meet the special needs of various groups of patients.

5.3 Pain Management and Patient Comfort Innovations

The advances in pain control and patient comfort have significantly improved patient experience in the dentistry sphere. The practices have become less uncomfortable with less invasive practices, better forms of applying local anesthesia and non-invasive technology such as laser. Other strategies that can be used in reducing anxiety and enhancing cooperation and behavioral interventions can also help reduce anxiety are distraction, relaxation and patient education [38].

These methods combined allow the patient to feel more relaxed and certain about the treatment procedure, which is crucial to further dental visits and oral health in the long term. Patient-centered care does not only focus on clinical effectiveness, but also the experience of care in general because comfort and satisfaction are the main factors of success in treatment.

5.4 Esthetic Dentistry and Patient Expectations

The increased popularity of esthetic dental treatment is an indicator of the increased value that is given to appearance and self-confidence. The future of restorative dentistry should therefore consider the expectations of the patient in terms of aesthetics i.e. color of the teeth, shape, and alignment. Digitized technologies, such as digital shade matching system, have enhanced the accuracy and consistency of the color choice and have provided more predictable and satisfactory outcomes [39].

The esthetic factors have a lot to do with patient satisfaction because individuals are more likely to gauge the effectiveness of the procedure by the visual outcomes. The clinicians must therefore talk to the patients about their expectations and provide them with helpful advice as to what is achievable. This is important congruency between expectations and outcomes that is vital in satisfying and gaining the trust of the patient.

5.5 Communication and Shared Decision-Making

Patient-centered care is based on effective communication. Easy and understanding communication assist in creating trust, decreasing anxiety, and enhancing patient knowledge of treatment choices. Shared decision-making is the process in which the patient is presented with evidence-based information regarding the treatments available, the possible risks and benefits of the treatment and their preferences are taken into account in the decision.

Studies indicate that patient involvement in the decision-making process results in improved satisfaction and compliance with treatment plans [35,36]. Moreover, patient satisfaction is becoming one of the significant measures of healthcare quality, which captures the clinical outcomes and the entire care experience [40]. Figure 3 presents a biopsychosocial model of patient-centered care in dentistry, which includes biological (oral health status, disease processes), psychological (anxiety, behavior, expectations), and social determinants.

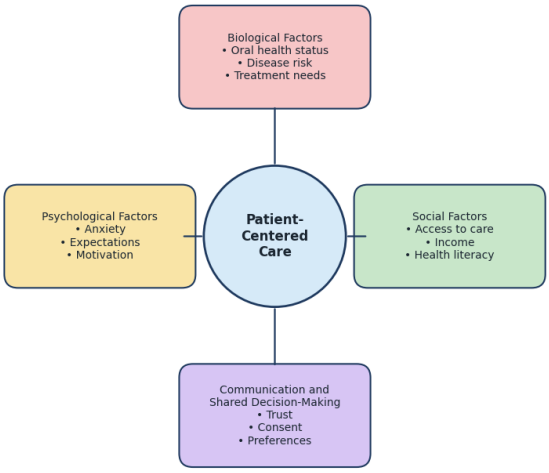

Figure 3: Model of Patient-Centered Care in Dentistry (Biopsychosocial Approach)

6. INTEGRATION OF DIGITAL DENTISTRY AND ARTIFICIAL INTELLIGENCE

Digital dentistry and artificial intelligence (AI) have greatly changed preventative and restorative dentistry. Such technologies allow providing increased diagnostic accuracy, effective treatment planning, and individual patient care. The state-of-the-art imaging and machine learning algorithms enable modern dentistry to be increasingly predictive, more precise, and more patient-centered.

6.1 AI in Diagnosis and Treatment Planning

AI is a robust dental diagnostic and clinical decision-making tool. Radiographs, intraoral imaging, and patient data can be analyzed using AI systems, especially, machine learning systems and deep learning systems to identify the early stages of dental caries, periodontal disease, and other oral diseases with the highest degree of accuracy. Such systems assist clinicians to identify lesions that might not have been identified easily using the conventional methods, and, therefore, improve early diagnosis and treatment [41].

In addition, AI enhances the treatment planning, merging the clinical outcomes with patient history and risk factors. This will allow better and evidence-based decisions and reduce clinical practice variability. The systematic reviews have also highlighted the greater reliability and applicability of AI to the field of dentistry, with the potential to further improve the efficiency and results [22].

6.2 Digital Smile Design (DSD)

Digital smile design (DSD) is a new application of digital technology, where aesthetic analysis and communication are merged with the patients. With digital imaging and software, clinicians are able to plan and preview the desired outcome of restorative and cosmetic procedures and then proceed with the procedures. This technology enhances better planning of the treatments because the dentist and the patient can evaluate different aesthetic options and make an informed decision.

DSD boosts predictability and patient satisfaction by aligning the clinical outcomes with patient expectations. It is also useful in the increase of interdisciplinary collaboration among dental professionals that also ensures the holistic approach to treatment. The integration of digital tools in the restorative processes has been proven to enhance the accuracy and efficiency of processes involved and to achieve better clinical outcomes [38].

6.3 Tele dentistry and Remote Monitoring

The use of tele dentistry as a mode of dental care delivery method has been a popular one, particularly in geographically remote areas that are underserved. It is the application of digital communication technology to hold consultations, diagnosis and follow-up care without necessarily being present. The tele dentistry also enhances access to care, time is not wasted in commuting and the oral health of the patients can be monitored at all times. Remote monitoring systems allow clinicians to track the progress of patients, assess the effectiveness of the treatment and take necessary measures in time. The technologies can be utilized especially in preventive care as they help to diagnose and treat oral conditions in their early stages. The latest advances in remote dentistry focus on its possible positive influence on the health care delivery and communication with patients [42].

6.4 Data-Driven Personalized Treatment

The development of individualized treatment approaches in the field of dentistry is now possible with the use of big data and advanced analytics. To identify trends and predict an illness, AI systems can analyze a big data set that includes clinical information, imaging information, and patient behavior. This assists in formulating individualized treatment plans that are unique to individual patients and his/her risk profile.

The combination of biological, behavioral and environmental variables to maximize the treatment results is called personalized health modeling. These measures, in addition to improving clinical effectiveness, patient satisfaction, fulfilling personal preferences, and expectations [43]. Data-driven strategies deployment is a major innovation in preventive and restorative dentistry, which follows the larger trend of precision healthcare.

6.5 Ethical Considerations and Limitations

Although digital dentistry and AI have many advantages, many ethical and practical issues need to be resolved. Concerns regarding data privacy, security, and patient consent are of utmost concern since digital systems are based on the gathering and processing of sensitive patient data. The confidentiality and integrity of this data is critical in ensuring that patients are confident in the information. Also, there are issues of accountability and decision-making with the dependence on AI. Although AI may be used to assist in clinical decisions, it must not take over the skills and judgment of dental professionals. Standardized guidelines and regulatory frameworks are also required to regulate the use of AI in dentistry.

In practical terms, the deployment of digital technologies can be expensive in terms of infrastructure, training, and maintenance. Such aspects can restrict access, especially in low-resource environments. Moreover, the dynamic nature of the technological process requires the unceasing learning and development of dental professionals [34,44]. Table 3 summarizes the various ways in which artificial intelligence and digital tools can be used in preventive and restorative dentistry, noting their use in diagnosis, treatment planning, and personalized care.

Table 3: Applications of AI and Digital Tools in Preventive and Restorative Dentistry

Application Area	Digital/AI Tool	Clinical Use	References
Diagnosis	AI-based image analysis	Early detection of caries, periodontal disease	[3]
Treatment Planning	Machine learning systems	Risk assessment and decision support	[22]
Aesthetic Dentistry	Digital Smile Design (DSD)	Visualization of treatment outcomes	[38]
Remote Care	Teledentistry platforms	Consultation, monitoring, follow-up	[42]
Personalized Care	Data analytics, predictive models	Individualized treatment planning	[43]
Workflow Integration	CAD/CAM, digital systems	Streamlined restorative procedures	[44]
Healthcare Systems	Digital transformation tools	Improved efficiency and service delivery	[34]

7. CHALLENGES, LIMITATIONS, AND FUTURE DIRECTIONS

Although there have been great improvements in preventive and restorative dentistry, a number of hurdles still hinder its extensive use. The high cost and low accessibility of sophisticated materials and digital technologies, especially in low-resource environments, is one of the main issues. Also, most of the modern methods and materials are highly technique sensitive and demand special training and lifelong professional development, so that they can give the highest output.

There are other challenges of long term stability and clinical stability of new bioactive materials and smart materials, and most of the innovations do not have long-

term clinical data. In addition, the privacy of data, data safety, and the necessity to standardize clinical guidelines are also regulatory and ethical issues related to the implementation of digital technologies and artificial intelligence.

Regenerative strategies, nanotechnology and precision dentistry are the future of dentistry and are designed to create a natural tooth structure, improve the performance of materials and offer the most personalized care. Further studies, budget cut and novel training model needed to introduce these innovations to the mainstream clinical practice.

8. CONCLUSION

The world of preventive and restorative dentistry is experiencing an unprecedented revolution, fueled by the development of the sphere of materials science, new clinical methods, and the introduction of digital technologies. Minimal to no invasive and patient centered care has greatly enhanced clinical outcomes and saved the natural tooth structure by replacing the previous and invasive care. The existing preventive measures that have increased the likelihood of controlling and preventing dental diseases at the early stages are risk-based management, bioactive agents and microbiome modulation. At the same time, the role of restorations is also redefined with the innovations in the restorative materials including bioactive, biomimetic and smart materials not as a passive replacement, but as a supplement to the oral health. The accuracy of the diagnosis, planning of the treatment and efficiency of the procedure have also been improved by the emerging technologies (CAD/CAM systems, 3D printing and artificial intelligence). The inventions have made it easier to deliver more specific, predictable and personalized dental treatment. However, the problems of cost, access and sensitivity of methods and ethical concerns are significant obstacles to mass adoption. These problems should be addressed through additional research, education and policy-making so as to maximise the benefits of these technologies. The last, yet definitely not the least, future of dentistry is the capacity of innovative materials, technologies and the patient-centered approach. With these innovations, dental practitioners will be able to offer more efficient, sustainable and personalized care and ultimately achieve improved oral health outcomes and quality of life to patients worldwide.

REFERENCES

1. Wen PYF, Chen MX, Zhong YJ, Dong QQ, Wong HM. Global Burden and Inequality of Dental Caries, 1990 to 2019. J Dent Res. 2022 Apr;101(4):392–9. doi:10.1177/00220345211056247
2. Frencken JE. Atraumatic restorative treatment and minimal intervention dentistry. British dental journal. 2017;223(3):183–9.
3. Schwendicke F, Samek W, Krois J. Artificial Intelligence in Dentistry: Chances and Challenges. J Dent Res. 2020 Jul;99(7):769–74. doi:10.1177/0022034520915714
4. Dobrzański LA, Dobrzański LB, Dobrzańska-Danikiewicz AD, Dobrzańska J. The concept of sustainable development of modern dentistry. Processes. 2020;8(12):1605.
5. Verma V, Gupta P, Singh P, Pandey NK. Biomaterials and Their Fabrication for Advanced Bionanocomposites: A Sustainable Approach. In: George SC, Tawiah B, editors. Advanced Bionanocomposite Materials [Internet]. Singapore: Springer Nature Singapore; 2025 [cited 2026 Apr 30]. p. 55–96. (Advanced Structured Materials). Available from: https://link.springer.com/10.1007/978-981-96-8225-6_2 doi:10.1007/978-981-96-8225-6_2
6. Al-Mutairi AS, Edris S, Sabbagh H, Al-Quwaie D, Alsubhi NH, Abulfaraj A, et al. Alteration of oral microbiome in children after using miswak (Salvadora persica l.) made from arak as a natural toothpaste. Appl Ecol Environ Res. 2020;18:7089–138.
7. Santonocito S, Ferlito S, Polizzi A, Ronsivalle V, Sclafani R, Valletta A, et al. Therapeutic and metagenomic potential of the biomolecular therapies against periodontitis and the oral microbiome: current evidence and future perspectives. International Journal of Molecular Sciences. 2022;23(22):13708.
8. Sulaiman TA, Alsahafi T, Stevenson III RG, Elgreatly A, Alkattan R, Alhalees S, et al. A Review of the Current Literature in Operative Dentistry: An Annual Report from the Research Committee of the Academy of Operative Dentistry. Operative Dentistry. 2025;50(6):576–98.
9. Kupka JR, Sagheb K, Al-Nawas B, Schiegnitz E. The Sympathetic Nervous System in Dental Implantology. Journal of Clinical Medicine. 2023;12(8):2907.
10. Nadine S, Elmar H, Werner G, Stefan R. Caries prevention in permanent teeth - basic recommendations of the German S 3 guideline. Clin Oral Invest. 2026 Apr 18;30(5):182. doi:10.1007/s00784-026-06880-1
11. Slayton RL, Urquhart O, Araujo MW, Fontana M, Guzmán-Armstrong S, Nascimento MM, et al. Evidence-based clinical practice guideline on nonrestorative treatments for carious lesions: a report from the American Dental Association. The Journal of the American Dental Association. 2018;149(10):837–49.
12. Zendron MP, Rocha A de O, Simões MS da S, Santana CM, Bolan M, Cardoso M. Fluoride varnish in dentistry: a bibliometric analysis of the 100 most-cited papers. Caries Research. 2023;57(3):189–96.
13. Satou R, Odaka K, Sako R, Ando M, Sugihara N. Improving Enamel Acid Resistance by an Intraoral Fluoride-Release Device Incorporating Cationic Hydroxy Cellulose Gel Using 3D Printer Molding. Materials. 2024;17(23):5731.
14. Kullashi Spahija F. Assessing the influence of calcium pre-treatment on enamel reactivity with different fluoride type solutions [PhD Thesis] [Internet]. Sveučilište u Zagrebu, Sveučilište u Zagrebu Stomatološki fakultet; 2025 [cited 2026 Apr 30]. Available from: https://repozitorij.sfzg.unizg.hr/object/sfzg:3032
15. Butera A, Maiorani C, Gallo S, Pascadopoli M, Quintini M, Lelli M, et al. Biomimetic action of zinc hydroxyapatite on remineralization of enamel and dentin: a review. Biomimetics. 2023;8(1):71.
16. Spatafora G, Li Y, He X, Cowan A, Tanner AC. The evolving microbiome of dental caries. Microorganisms. 2024;12(1):121.

17. Abdelaziz M. Detection, diagnosis, and monitoring of early caries: the future of individualized dental care. Diagnostics. 2023;13(24):3649.
18. Xie SX, Song L, Yuca E, Boone K, Sarikaya R, VanOosten SK, et al. Antimicrobial Peptide–Polymer Conjugates for Dentistry. ACS Appl Polym Mater. 2020 Mar 13;2(3):1134–44. doi:10.1021/acsapm.9b00921
19. Laajala A. Caries experience among adults in Northern Finland: association with oral hygiene and genetic factors [Internet]. 2022 [cited 2026 Apr 30]. Available from: https://oulurepo.oulu.fi/handle/10024/36930
20. Pinto NS, Jorge GR, Vasconcelos J, Probst LF, De-Carli AD, Freire A. Clinical efficacy of bioactive restorative materials in controlling secondary caries: a systematic review and network meta-analysis. BMC Oral Health. 2023 Jun 15;23(1):394. doi:10.1186/s12903-023-03110-y
21. Ferracane JL. A historical perspective on dental composite restorative materials. Journal of Functional Biomaterials. 2024;15(7):173.
22. Abd Khader RM. Artificial Intelligence in Dentistry: A Systematic Literature Review of Clinical Applications and Challenges [Internet]. 2026 [cited 2026 Apr 30]. Available from: https://www.researchgate.net/profile/Rawan-Mohammed-12/publication/403460770_Artificial_Intelligence_in_Dentistry_A_Systematic_Literature_Review_of_Clinical_Applications_and_Challenges2026/links/69ced58fac3812287565d6c9/Artificial-Intelligence-in-Dentistry-A-Systematic-Literature-Review-of-Clinical-Applications-and-Challenges2026.pdf
23. Pandey A. Advancements in dental materials for restorative dentistry: a focus on bioactive glass ionomer cement. Clin Res Clin Rep. 2024;5:1–3.
24. Li F, Lu D, Li X, Ye Y, Zhi C, Chen X, et al. A Novel Amyloid Hydrogel With Remineralizing and Antibacterial Properties for Interrupting Dental Caries
  [SSRN Scholarly Paper] [Internet]. Rochester, NY: Social Science Research Network; 2025 [cited 2026 Apr 30]. Available from: https://papers.ssrn.com/abstract=5654651 doi:10.2139/ssrn.5654651
25. Zhang OL, Niu JY, Yin IX, Yu OY, Mei ML, Chu CH. Bioactive materials for caries management: A literature review. Dentistry journal. 2023;11(3):59.
26. Hollanders ACC. Closing the gap: Modifying factors in secondary caries [Internet]. 2022 [cited 2026 Apr 30]. Available from: https://repository.ubn.ru.nl/bitstream/handle/2066/250219/250219.pdf
27. Daghriri FA, Alharbi EA, Najar AA, Ali AM. Biocompatible Issues Related to Restorative Dental Material-I (Regulations, Interfaces, Measuring Tests). Journal of Advanced Medical and Dental Sciences Research. 2024;12(1):20–6.
28. Prause E, Hey J, Beuer F, Yassine J, Hesse B, Weitkamp T, et al. Microstructural investigation of hybrid CAD/CAM restorative dental materials by micro-CT and SEM. Dental Materials. 2024;40(6):930–40.
29. Nizami MZI, Jindarojanakul A, Ma Q, Lee SJ, Sun J. Advances in bioactive dental adhesives for caries prevention: a state-of-the-art review. Journal of Functional Biomaterials. 2025;16(11):418.
30. Gupta S, Jawanda MK. Laser as a promising non-invasive technique to treat oral submucous fibrosis: a systematic review of the literature. The Saudi dental journal. 2021;33(7):413–23.
31. Pachiou A, Zervou E, Tsirogiannis P, Sykaras N. Evaluation of the marginal fit of lithium disilicate single crowns fabricated with the conventional (IPS e. max Press) and CAD/CAM (IPS e. max CAD) methods: a systematic review and meta-analysis. International Journal of Computerized Dentistry [Internet]. 2024 [cited 2026 Apr 30];27(4). Available from: https://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=14634201&AN=182540976&h=F1Ns48CDT0g%2B8%2BxFZWh6QwLtUHTBR%2FzgDS%2FAWXucJDyj5CLuOX7ZSsE7LsyTGeCrrEAJ%2Bp67Aq0bAUVehv2S6A%3D%3D&crl=c
32. Prasad S, Kader NA, Sujatha G, Raj T, Patil S. 3D Printing in Dentistry. J 3D Print Med. 2018 Jul 31;2(3):89–91. doi:10.2217/3dp-2018-0012
33. Atasever E. Bond Strength and Adhesive Performance of 3D-Printed Dental Materials. Innovative Applications and Research Methods in Health Sciences. 2025;683.
34. Larsson A, Teigland R. Digital transformation and public services [Internet]. Routledge; 2019 [cited 2026 Apr 30]. Available from: https://api.taylorfrancis.com/content/books/mono/download?identifierName=doi&identifierValue=10.4324/9780429319297&type=googlepdf
35. Goldberger T, Gasner-Margolin R, Paul RA, Jaramillo DE. Evidence-Based Decision-Making in Dentistry: The Endodontic Perspective. In: Rosen E, Nemcovsky CE, Tsesis I, editors. Evidence-Based Decision Making in Dentistry [Internet]. Cham: Springer Nature Switzerland; 2026 [cited 2026 Apr 30]. p. 21–41. Available from: https://link.springer.com/10.1007/978-3-032-03561-5_3 doi:10.1007/978-3-032-03561-5_3
36. Felgner S, Handrock JF, Schroll CC, Schütte F, Henschke C. Decision-making regarding dental treatments–What factors matter from patients' perspective and does Covid-19 influence patients' behavior? A systematic review [Internet]. 2023 [cited 2026 Apr 30]. Available from: https://www.researchsquare.com/article/rs-3372636/latest
37. Singh A, Antunes JLF, Peres MA. Socio-Economic Inequalities in Oral Health. In: Peres MA, Antunes JLF, Watt RG, editors. Oral Epidemiology [Internet]. Cham: Springer International Publishing; 2021 [cited 2026 Apr 30]. p. 279–94. (Textbooks in Contemporary Dentistry). Available from: https://link.springer.com/10.1007/978-3-030-50123-5_17 doi:10.1007/978-3-030-50123-5_17
38. Alqahtani SAH. Enhancing dental practice: cutting-edge digital innovations. Brazilian Journal of Oral Sciences. 2024;23:e244785.
39. Rashid F, Farook TH, Dudley J. Digital shade matching in dentistry: a systematic review. Dentistry Journal. 2023;11(11):250.

40. Gao Q, Liu M, Peng L, Zhang Y, Shi Y, Teuwen DE, et al. Patient satisfaction and its health provider-related determinants in primary health facilities in rural China. BMC Health Serv Res. 2022 Dec;22(1):946. doi:10.1186/s12913-022-08349-9
41. Schwendicke F, Splieth CH, Bottenberg P, Breschi L, Campus G, Doméjean S, et al. How to intervene in the caries process in adults: proximal and secondary caries? An EFCD-ORCA-DGZ expert Delphi consensus statement. Clin Oral Invest. 2020 Sep;24(9):3315–21. doi:10.1007/s00784-020-03431-0
42. Shoaib LA, Mohamed Rohani M, Gonzalez MAG, Lin GSS. Remote Dentistry: Potential Applications and Challenges. In: Rahman MT, Kassim NLA, editors. Handbook of Dental Education Technology [Internet]. Singapore: Springer Nature Singapore; 2025 [cited 2026 Apr 30]. p. 1–31. Available from: https://link.springer.com/10.1007/978-981-97-0275-6_29-1 doi:10.1007/978-981-97-0275-6_29-1
43. Paromita P, Mundnich K, Nadarajan A, Booth BM, Narayanan SS, Chaspari T. Modeling inter-individual differences in ambulatory-based multimodal signals via metric learning: a case study of personalized well-being estimation of healthcare workers. Frontiers in Digital Health. 2023;5:1195795.
44. Khurshid Z, Zafar MS, Rokaya D. Prosthodontics and Restorative Dentistry: Latest Advances in Digital Technologies [Internet]. CRC Press; 2026 [cited 2026 Apr 30]. Available from: https://books.google.com/books?hl=en&lr=&id=P-OdEQAAQBAJ&oi=fnd&pg=PP8&dq=Revilla-Le%C3%B3n,+M.,+%26+%C3%96zcan,+M.+(2020).+Digital+dentistry+workflow.+Journal+of+Prosthodontics,+29(2),+99%E2%80%93104.&ots=OGXxpM0KEL&sig=Nk0nBijCon9qXzhEsiZxdgDX7Fg