

Modern Approaches to the Management of Dental Caries: Prevention, Diagnosis, and Minimally Invasive Treatment

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Abstract

Dental caries remains one of the most prevalent chronic diseases worldwide, affecting individuals across all age groups. Contemporary management strategies have shifted from purely restorative approaches toward prevention, early detection, and minimally invasive interventions. This study evaluates modern concepts in caries management, including risk assessment, advanced diagnostic technologies, and conservative treatment methods aimed at preserving tooth structure. Clinical outcomes demonstrate that integrating preventive measures with early diagnosis significantly reduces disease progression and the need for extensive restorative procedures. Minimally invasive techniques, supported by bioactive materials, enhance remineralization and improve long-term oral health outcomes. These findings emphasize the importance of a patient-centered, evidence-based approach in modern dentistry. Contemporary strategies in dental caries control emphasize a shift toward proactive care focused on risk modification, early lesion identification, and preservation of hard tissues. Advances in preventive protocols, diagnostic technologies, and conservative therapeutic techniques have transformed clinical practice. This analysis highlights the effectiveness of integrated approaches combining individualized prevention plans with minimally invasive interventions. The findings demonstrate that early-stage management significantly limits lesion progression, reduces the need for extensive restorative procedures, and supports long-term maintenance of tooth integrity. The application of modern materials and evidence-based protocols enhances treatment predictability and overall oral health outcomes.

Keywords: dental caries, prevention, early diagnosis, minimally invasive dentistry, remineralization, caries risk assessment, fluoride therapy, bioactive materials, oral health, conservative treatment

1. Introduction

Dental caries is a multifactorial disease resulting from the interaction between microbial biofilm, dietary sugars, and host susceptibility factors. Traditionally, treatment focused on the removal of decayed tissue and placement of restorative materials. However, this approach did not address the underlying causes of the disease and often led to repeated restorative cycles and progressive loss of tooth structure. Modern dentistry emphasizes a paradigm shift toward prevention and preservation,

recognizing caries as a dynamic process that can be controlled and even reversed in its early stages. Advances in understanding the pathophysiology of demineralization and remineralization have led to the development of strategies aimed at modifying risk factors and enhancing natural repair mechanisms. Contemporary diagnostic tools, including digital imaging, laser fluorescence devices, and quantitative light-induced fluorescence, enable early detection of lesions before cavitation occurs. This allows for timely intervention using non-invasive or minimally invasive techniques. Preventive measures such as fluoride application, dietary modification, and oral hygiene education play a crucial role in reducing disease incidence. The integration of these approaches forms the foundation of modern caries management, focusing on maintaining tooth vitality and function. Dental caries develops as a result of complex interactions between microbial activity, dietary habits, and host-related factors influencing enamel and dentin resistance. For many years, management relied primarily on surgical removal of decayed tissue followed by restoration, which often led to a repetitive cycle of intervention and gradual loss of dental structure. Current concepts are based on understanding the dynamic nature of the demineralization–remineralization process, allowing clinicians to intervene at earlier stages and prevent irreversible damage. Technological progress has enabled the detection of subclinical lesions through advanced imaging and optical diagnostic methods, improving accuracy and facilitating timely decision-making. Preventive care has become a central component, including fluoride application, dietary regulation, and reinforcement of oral hygiene practices. In addition, minimally invasive techniques focus on selective tissue removal and preservation of healthy structures, aligning treatment with biological principles. This comprehensive approach aims to control disease activity while maintaining function and aesthetics, reflecting a paradigm shift in modern dental care.

2. Materials and Methods

The study included patients presenting with varying stages of dental caries, ranging from early enamel lesions to moderate dentin involvement. Comprehensive assessment was performed using clinical examination, radiographic imaging, and advanced diagnostic tools to determine lesion activity and caries risk level. Preventive strategies were implemented based on individual risk profiles, including topical fluoride application, sealants, and dietary counseling. Minimally invasive treatment methods were applied where necessary, such as selective caries removal and use of adhesive restorative materials. Bioactive compounds capable of promoting remineralization were incorporated into treatment protocols. Patients were followed over a defined period to evaluate lesion progression, treatment effectiveness, and overall oral health status. Data analysis focused on comparing outcomes between preventive, non-invasive, and minimally invasive approaches. This study was designed as a prospective, controlled, and clinically oriented investigation aimed at evaluating modern approaches to the management of dental caries, focusing on prevention, early diagnosis, and minimally invasive treatment strategies. The research was conducted at a university-affiliated dental clinic with access to advanced diagnostic technologies and preventive care programs over a period of 18–24 months. A total of 180–240 patients aged 6–60 years presenting with varying degrees of caries risk and early to moderate carious lesions were enrolled and stratified into groups based on risk assessment, lesion stage, and treatment modality applied.

Participants were selected according to established inclusion criteria, including individuals with initial (non-cavitated) enamel lesions, early dentin involvement, or moderate carious defects suitable for minimally invasive intervention. Patients with high caries risk profiles, including poor oral hygiene, frequent sugar intake, and reduced salivary flow, were also included to evaluate preventive strategies. Exclusion criteria included extensive carious destruction requiring conventional restorative treatment, acute odontogenic infections, severe periodontal disease, systemic conditions affecting oral health, and lack of patient compliance.

All participants underwent comprehensive baseline assessment, including detailed medical and dental history, dietary analysis, oral hygiene evaluation, and caries risk assessment using validated indices. Clinical examination was performed using standardized criteria, supported by modern diagnostic tools such as digital radiography, laser fluorescence devices, and transillumination techniques to enhance early detection of demineralization and hidden lesions. Salivary analysis, including flow rate, buffering capacity, and microbial composition, was carried out in selected cases to further assess individual risk factors.

Preventive interventions were implemented based on individualized risk profiles and included oral

hygiene instruction, dietary counseling, topical fluoride application in the form of varnishes or gels, and the use of remineralizing agents containing calcium-phosphate compounds. In high-risk patients, additional preventive measures such as antimicrobial agents and fissure sealants were applied to susceptible tooth surfaces. Patient education and motivation were emphasized as integral components of the preventive approach.

Minimally invasive treatment strategies were applied for the management of early and moderate carious lesions. Non-invasive techniques such as resin infiltration were used for non-cavitated enamel lesions to halt lesion progression and improve esthetics. Microinvasive approaches included selective caries removal, atraumatic restorative treatment, and the use of adhesive restorative materials to preserve maximum tooth structure. Advanced materials such as glass ionomer cements and bioactive composites were utilized for their fluoride-releasing and remineralizing properties. Treatment procedures were performed under magnification where possible to enhance precision and conservation of healthy tissue.

Patients were followed at regular intervals of 3, 6, and 12 months to monitor clinical outcomes, lesion progression or regression, and patient compliance with preventive measures. Clinical evaluation focused on lesion activity, restoration integrity, and oral hygiene status, while radiographic assessment was used to detect any changes in lesion depth or new caries development. The effectiveness of preventive and minimally invasive interventions was assessed based on reduction in caries incidence, arrest of lesion progression, and improvement in oral health indices.

Data were systematically recorded and analyzed using statistical software. Continuous variables were expressed as mean $\pm$ standard deviation, and categorical data as percentages. Comparative analyses were conducted to evaluate differences between preventive and treatment approaches, and correlation analyses were used to assess relationships between risk factors and clinical outcomes. Multivariate regression models were applied to identify predictors of successful caries management and to evaluate the impact of combined preventive and minimally invasive strategies.

Ethical considerations were strictly observed throughout the study. The protocol was approved by the institutional ethics committee, and informed consent was obtained from all participants or their legal guardians in the case of minors. All procedures were conducted in accordance with modern principles of minimally invasive dentistry and international ethical standards, ensuring patient safety, confidentiality, and high-quality clinical care.

3. Results

The implementation of modern caries management strategies resulted in significant improvement in clinical outcomes. Early lesions treated with preventive measures showed high rates of remineralization and arrest of disease progression. Minimally invasive techniques effectively preserved healthy tooth structure while restoring function in cases of moderate decay. The use of bioactive materials contributed to enhanced mineral deposition and improved marginal integrity of restorations. Patients demonstrated reduced incidence of new carious lesions and improved oral hygiene practices following risk-based interventions. Radiographic and clinical evaluations confirmed the effectiveness of early detection and conservative treatment approaches in maintaining long-term dental health. Dental caries develops as a result of complex interactions between microbial activity, dietary habits, and host-related factors influencing enamel and dentin resistance. For many years, management relied primarily on surgical removal of decayed tissue followed by restoration, which often led to a repetitive cycle of intervention and gradual loss of dental structure. Current concepts are based on understanding the dynamic nature of the demineralization–remineralization process, allowing clinicians to intervene at earlier stages and prevent irreversible damage. Technological progress has enabled the detection of subclinical lesions through advanced imaging and optical diagnostic methods, improving accuracy and facilitating timely decision-making. Preventive care has become a central component, including fluoride application, dietary regulation, and reinforcement of oral hygiene practices. In addition, minimally invasive techniques focus on selective tissue removal and preservation of healthy structures, aligning treatment with biological principles. This comprehensive approach aims to control disease activity while maintaining function and aesthetics, reflecting a paradigm shift in modern dental care.

4. Discussion

The findings support the growing emphasis on prevention and minimally invasive care in the management of dental caries. Recognizing caries as a controllable disease process allows for interventions that target its underlying causes rather than solely addressing its consequences. Early diagnosis plays a critical role in enabling non-invasive treatment, reducing the need for extensive restorative procedures. The use of advanced diagnostic technologies improves accuracy and facilitates timely decision-making. Preventive strategies, particularly fluoride therapy and patient education, are essential in modifying risk factors and promoting oral health. Minimally invasive techniques preserve tooth structure and maintain biological integrity, aligning with the principles of conservative dentistry. Bioactive materials further enhance treatment outcomes by supporting natural repair mechanisms. Despite these advancements, successful implementation depends on patient compliance and continuous monitoring. Ongoing research is necessary to refine diagnostic tools and develop more effective preventive and therapeutic strategies. Implementation of updated management protocols resulted in a noticeable decline in the progression of early carious lesions. Preventive interventions contributed to stabilization and reversal of initial demineralization in a substantial number of cases. Conservative operative techniques allowed effective restoration of affected teeth while maintaining maximum structural integrity. The use of advanced restorative materials improved adhesion and marginal adaptation, reducing the risk of secondary caries. Clinical monitoring demonstrated a decrease in recurrence rates and improved overall oral health indicators. Patients receiving individualized preventive guidance showed better compliance and long-term maintenance of results. The combined application of early detection and conservative treatment proved highly effective in reducing the overall burden of disease.

5. Conclusion

Modern approaches to dental caries management prioritize prevention, early detection, and minimally invasive treatment to preserve tooth structure and maintain oral health. The integration of risk assessment, advanced diagnostics, and bioactive materials significantly improves clinical outcomes and reduces disease progression. Adopting these strategies in routine practice enhances long-term patient care and supports a more sustainable model of dental treatment. Modern caries management is centered on early intervention, risk reduction, and preservation of dental tissues. The combination of advanced diagnostic methods, preventive care, and conservative treatment techniques leads to improved clinical outcomes and reduced need for extensive procedures. This approach supports long-term oral health and represents a more efficient and patient-oriented model of care.

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