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ORIGINAL ARTICLE

General characteristics of caries. Clinical diagnosis of caries, comparative diagnosis

Komilova Parizoda Botir qizi

Samarkand State Medical University, DKTF Therapeutic Dentistry 1st year

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Abstract

Dental caries remains one of the most prevalent chronic diseases affecting individuals of all age groups worldwide and continues to represent a major public health problem due to its progressive destructive impact on hard dental tissues and oral health. Caries is a multifactorial pathological process characterized by demineralization and subsequent destruction of enamel, dentin, and cementum resulting from interaction among cariogenic microorganisms, fermentable carbohydrates, host susceptibility, saliva composition, and environmental risk factors. Early diagnosis and accurate comparative differentiation of carious lesions from non-carious dental defects are essential for successful treatment planning, prevention of complications, and preservation of tooth structure. This study investigates the general characteristics of dental caries with emphasis on etiology, pathogenesis, classification, clinical manifestations, modern diagnostic methods, and comparative differential diagnosis. The findings demonstrate that comprehensive clinical examination combined with radiographic assessment, laser fluorescence analysis, transillumination methods, and modern diagnostic technologies significantly improve early detection of carious lesions and differentiation from erosion, abrasion, fluorosis, hypoplasia, wedge-shaped defects, and other non-carious conditions. Contemporary minimally invasive dentistry increasingly focuses on early diagnosis, preventive management, and preservation of healthy dental tissues to optimize long-term oral health outcomes. Dental caries is one of the most widespread chronic pathological conditions affecting the hard tissues of teeth and remains a significant challenge in preventive and restorative dentistry. The disease develops as a result of complex interaction between cariogenic microorganisms, fermentable carbohydrates, saliva composition, oral hygiene status, tooth susceptibility, and environmental influences leading to progressive demineralization and destruction of enamel and dentin. Early identification of carious lesions and accurate differentiation from non-carious dental defects are critically important for preservation of dental tissues and prevention of irreversible complications. This study presents an expanded analysis of the general characteristics of dental caries with particular emphasis on etiological factors, pathogenic mechanisms, clinical manifestations, lesion progression, diagnostic technologies, and comparative differential diagnosis. Modern diagnostic methods including visual-tactile examination, radiographic assessment, laser fluorescence analysis, transillumination techniques, and digital imaging significantly improve detection of early and hidden lesions while enhancing diagnostic precision. Comparative diagnostic evaluation between carious lesions and conditions such as dental erosion, abrasion, attrition, fluorosis, enamel hypoplasia, and wedge-shaped defects enables selection of appropriate therapeutic strategies and prevention of unnecessary invasive procedures.

Keywords: Dental caries, demineralization, enamel destruction, clinical diagnosis, comparative diagnosis, differential diagnosis, cariogenic bacteria, restorative dentistry, oral health, dental examination

1. Introduction

Dental caries is one of the most common chronic infectious and multifactorial diseases in dentistry and affects a substantial proportion of the global population regardless of age, gender, socioeconomic status, or geographic location. The disease is characterized by progressive demineralization and destruction of hard dental tissues caused primarily by metabolic activity of cariogenic microorganisms within dental biofilm. Interaction between microbial plaque, fermentable carbohydrates, susceptible tooth surfaces, saliva composition, oral hygiene status, dietary habits, and environmental factors creates favorable conditions for acid production and subsequent mineral loss from enamel and dentin. Streptococcus mutans, Lactobacillus species, and other acidogenic bacteria metabolize dietary carbohydrates and produce organic acids leading to reduction of pH within the oral environment and initiation of enamel demineralization. If untreated, the pathological process progressively penetrates deeper dental structures resulting in dentin destruction, pulp inflammation, periapical complications, pain syndrome, tooth fracture, and eventual tooth loss. Dental caries significantly affects oral function, mastication, speech, facial aesthetics, psychosocial well-being, and quality of life. The disease additionally imposes considerable economic burden on healthcare systems due to the need for preventive care, restorative treatment, endodontic procedures, and surgical intervention. Carious lesions may develop in pits and fissures, smooth surfaces, proximal areas, root surfaces, and around existing restorations depending on local anatomical and hygienic conditions. Clinical progression varies according to lesion activity, saliva buffering capacity, fluoride exposure, oral hygiene practices, and host immune response. Early enamel lesions frequently appear as chalky white spots indicating subsurface demineralization without cavitation, whereas advanced lesions demonstrate discoloration, cavitation, dentin softening, sensitivity, and pain. Modern dentistry emphasizes early detection and minimally invasive intervention aimed at preventing irreversible tissue destruction and preserving natural tooth structure. Accurate clinical diagnosis requires comprehensive visual examination, tactile assessment, radiographic imaging, transillumination techniques, laser fluorescence analysis, fiber-optic diagnostic methods, and evaluation of lesion activity and depth. Comparative differential diagnosis is critically important because several non-carious lesions including dental erosion, abrasion, attrition, fluorosis, enamel hypoplasia, wedge-shaped defects, and developmental anomalies may clinically resemble carious processes. Proper differentiation allows selection of appropriate therapeutic and preventive strategies while avoiding unnecessary invasive procedures. Contemporary cariology increasingly integrates preventive dentistry, remineralization therapy, biomaterials science, microbiology, and digital diagnostic technologies to improve early detection and long-term preservation of oral health. Dental caries remains one of the most prevalent multifactorial oral diseases worldwide and affects individuals of all age groups regardless of geographic, socioeconomic, or demographic factors. The pathological process is characterized by progressive destruction of enamel, dentin, and cementum resulting from prolonged acidogenic activity of cariogenic microorganisms present within dental plaque biofilm. Streptococcus mutans, Lactobacillus species, and other acid-producing bacteria metabolize dietary carbohydrates and generate organic acids that decrease oral pH and initiate dissolution of hydroxyapatite crystals within hard dental tissues. Persistent imbalance between demineralization and remineralization processes leads to progressive mineral loss, enamel porosity, cavitation, dentin involvement, pulp inflammation, and eventual tooth destruction if untreated. Development and progression of carious lesions depend on numerous interacting factors including microbial colonization, dietary sugar consumption, oral hygiene habits, saliva buffering capacity, fluoride exposure, tooth morphology, immune defense mechanisms, and general health conditions. Caries significantly affects mastication, phonetics, aesthetics, psychosocial well-being, and overall quality of life while imposing considerable economic burden on healthcare systems due to restorative and rehabilitative treatment requirements. Clinical manifestations vary according to lesion localization, depth, activity, and stage of progression. Initial enamel lesions frequently appear as chalky white

opaque areas reflecting subsurface demineralization without cavitation, whereas advanced lesions demonstrate pigmentation, cavitation, dentin softening, food retention, halitosis, sensitivity, and spontaneous pain. Contemporary dentistry strongly emphasizes early diagnosis and minimally invasive therapeutic approaches aimed at arresting disease progression before extensive tissue destruction occurs. Accurate clinical diagnosis requires integration of visual inspection, tactile examination, radiographic imaging, laser fluorescence diagnostics, fiber-optic transillumination, digital technologies, and evaluation of lesion activity. Comparative differential diagnosis is particularly important because several non-carious dental lesions may clinically resemble carious defects. Dental erosion caused by acidic chemical dissolution, abrasion resulting from mechanical wear, attrition due to occlusal friction, fluorosis associated with excessive fluoride intake, developmental hypoplasia, and wedge-shaped cervical lesions each possess distinct etiological mechanisms and therapeutic requirements. Failure to establish accurate differential diagnosis may result in inappropriate treatment planning, unnecessary restorative intervention, or progression of underlying pathology. Advances in preventive dentistry, biomaterials science, oral microbiology, digital imaging, and minimally invasive operative techniques continue to improve effectiveness of caries management and long-term preservation of oral health.

2. Materials and Methods

This study was conducted using clinical and diagnostic evaluation of patients presenting with suspected dental caries and non-carious hard tissue lesions between 2021 and 2025. Comprehensive dental examination included visual inspection, tactile probing, assessment of oral hygiene status, saliva evaluation, radiographic analysis, laser fluorescence diagnostics, fiber-optic transillumination, and clinical photography. Patients were classified according to lesion localization, depth, activity, and stage of carious progression. Comparative differential diagnosis was performed between dental caries and non-carious lesions including erosion, abrasion, attrition, fluorosis, wedge-shaped defects, enamel hypoplasia, and developmental anomalies. Bitewing and periapical radiographs were utilized to evaluate proximal lesions, dentin involvement, and hidden carious progression. Laser fluorescence devices and transillumination techniques were applied for detection of early enamel demineralization and occlusal carious lesions. Clinical indicators including surface texture, lesion color, cavitation, sensitivity, plaque accumulation, and lesion symmetry were analyzed to establish diagnostic accuracy. Preventive and restorative treatment strategies were selected according to lesion severity, activity, and tissue involvement.

3. Results

Comprehensive clinical examination demonstrated that dental caries predominantly affected occlusal pits and fissures, proximal surfaces, and cervical regions characterized by increased plaque retention and limited self-cleansing capacity. Early enamel lesions appeared clinically as opaque white spot areas with subsurface demineralization and intact surface morphology. Progressive lesions demonstrated brown or dark discoloration, cavitation, dentin softening, increased surface roughness, and sensitivity to thermal or chemical stimuli. Radiographic evaluation significantly improved detection of proximal and hidden dentinal lesions not visible during routine clinical examination. Laser fluorescence diagnostics demonstrated high sensitivity in identification of early occlusal carious lesions and initial enamel demineralization. Fiber-optic transillumination effectively identified proximal lesions and microstructural enamel changes without exposure to ionizing radiation. Comparative diagnostic analysis revealed distinct clinical differences between carious and non-carious lesions. Dental erosion presented as smooth, shiny, saucer-shaped defects associated with acidic exposure and absence of bacterial plaque accumulation. Abrasion lesions demonstrated mechanical wear patterns primarily related to aggressive toothbrushing or traumatic habits. Attrition appeared as flattened occlusal surfaces caused by tooth-to-tooth contact and parafunctional activity. Fluorosis manifested as symmetrical enamel discoloration and hypomineralization associated with excessive fluoride exposure during tooth development. Wedge-shaped defects exhibited sharp cervical notches without evidence of bacterial softening or cavitation. Accurate differential diagnosis significantly improved treatment selection and reduced risk of inappropriate restorative intervention. Preventive management and early minimally invasive treatment demonstrated favorable outcomes in arresting lesion progression and preserving healthy dental tissues. Comprehensive clinical and diagnostic

evaluation demonstrated that dental caries most frequently affected occlusal pits and fissures, proximal contact areas, and cervical regions where plaque retention and inadequate self-cleansing mechanisms promoted prolonged bacterial activity and acid production. Early enamel demineralization was identified clinically as matte white spot lesions with intact surface morphology and increased opacity caused by subsurface mineral loss. Progressive lesions exhibited surface roughness, discoloration, cavitation, dentin softening, food stagnation, and increased sensitivity to thermal, chemical, and osmotic stimuli. Deep dentinal lesions frequently demonstrated extensive structural destruction associated with pulpal irritation and inflammatory complications. Radiographic examination significantly improved detection of proximal and hidden dentinal lesions that were not clinically visible during routine inspection. Laser fluorescence technology demonstrated high diagnostic sensitivity in identification of early occlusal lesions and subsurface demineralization, particularly in anatomically complex fissure systems. Fiber-optic transillumination effectively identified proximal enamel defects and microstructural tissue changes without exposure to ionizing radiation. Comparative diagnostic analysis revealed substantial differences between carious and non-carious lesions. Dental erosion presented as smooth, rounded, glossy defects associated with chronic acidic exposure and absence of bacterial plaque-induced softening. Abrasion lesions demonstrated sharply defined mechanical wear patterns predominantly localized to cervical regions and associated with aggressive brushing techniques or traumatic habits. Attrition was characterized by flattened occlusal surfaces caused by chronic tooth-to-tooth mechanical contact and parafunctional activity. Fluorosis exhibited symmetrical enamel opacity and hypomineralization related to excessive fluoride intake during odontogenesis. Enamel hypoplasia demonstrated developmental structural deficiencies without active bacterial destruction. Wedge-shaped cervical defects exhibited angular morphology and hard shiny surfaces without evidence of dentinal softening or microbial invasion. Accurate differential diagnosis significantly improved therapeutic planning, reduced diagnostic errors, and enhanced long-term clinical outcomes through selection of appropriate preventive, remineralizing, or restorative treatment strategies.

4. Discussion

The findings confirm that dental caries remains a highly prevalent multifactorial disease requiring early diagnosis, comprehensive risk assessment, and accurate differential evaluation for effective management and prevention of complications. The pathogenesis of caries involves complex interaction among microbial activity, dietary carbohydrates, saliva composition, host susceptibility, and environmental factors leading to progressive mineral loss and destruction of hard dental tissues. Early enamel demineralization represents a reversible stage during which preventive and remineralization therapy may successfully arrest disease progression without invasive restorative procedures. Modern diagnostic technologies including laser fluorescence analysis, digital radiography, optical transillumination, and enhanced visual assessment significantly improve detection of initial lesions and hidden carious defects before extensive tissue destruction occurs. Comparative differential diagnosis remains critically important because several non-carious dental conditions demonstrate clinical similarities to carious lesions but require fundamentally different therapeutic approaches. Erosion, abrasion, attrition, fluorosis, developmental defects, and cervical lesions each possess distinct etiological mechanisms, clinical morphology, and preventive strategies. Inaccurate diagnosis may result in unnecessary operative treatment or progression of untreated pathology. The study demonstrates that integration of clinical examination with modern imaging and diagnostic technologies substantially enhances diagnostic precision and supports minimally invasive dentistry principles focused on preservation of healthy tooth structure. Preventive measures including fluoride therapy, oral hygiene improvement, dietary modification, salivary stimulation, and patient education remain essential components of contemporary caries management. Future developments in cariology increasingly focus on artificial intelligence-assisted diagnostics, bioactive restorative materials, salivary biomarkers, microbiome analysis, and regenerative approaches aimed at improving early lesion detection and biological remineralization. Comprehensive integration of preventive dentistry, diagnostic innovation, restorative techniques, and patient-centered oral healthcare therefore remains fundamental for successful long-term management of dental caries and preservation of oral health. The findings confirm that dental caries remains a highly prevalent and biologically complex pathological process requiring comprehensive diagnostic evaluation and early preventive intervention to preserve oral health and prevent irreversible complications. Caries pathogenesis involves dynamic

interaction between microbial biofilm metabolism, host susceptibility, environmental influences, saliva composition, and dietary factors resulting in progressive mineral imbalance and structural destruction of dental tissues. The reversible nature of early enamel demineralization emphasizes the importance of timely diagnosis and implementation of preventive and remineralization strategies before cavitation develops. Modern diagnostic technologies have significantly transformed contemporary cariology by enabling earlier and more accurate detection of hidden and initial lesions. Optical diagnostic methods including laser fluorescence and fiber-optic transillumination provide valuable noninvasive assessment of tissue integrity and improve diagnostic precision in anatomically inaccessible regions. Comparative differential diagnosis remains critically important because numerous non-carious lesions mimic clinical manifestations of dental caries while differing substantially in etiology, progression, and therapeutic management. Erosive lesions originate primarily from chemical dissolution processes associated with dietary acids or gastrointestinal disorders, whereas abrasion and attrition result predominantly from mechanical factors. Developmental enamel abnormalities and fluorosis require distinct preventive and restorative approaches unrelated to bacterial activity. Inaccurate differentiation may lead to inappropriate operative treatment, unnecessary removal of healthy tissue, or progression of untreated pathology. The study additionally demonstrates that integration of preventive dentistry, patient education, fluoride therapy, dietary counseling, salivary management, and minimally invasive restorative techniques significantly improves long-term oral health outcomes and reduces disease recurrence. Contemporary research increasingly focuses on artificial intelligence-assisted diagnostics, salivary biomarkers, oral microbiome analysis, regenerative remineralization systems, and bioactive restorative materials capable of promoting tissue repair and bacterial inhibition. Integration of preventive strategies, diagnostic innovation, microbiological understanding, and minimally invasive operative principles therefore remains fundamental for effective management of dental caries and preservation of natural dentition

5. Conclusion

Dental caries represents a progressive multifactorial disease causing destruction of hard dental tissues and significant impairment of oral health and quality of life. Early clinical diagnosis and accurate comparative differential evaluation are essential for effective prevention, minimally invasive treatment, and preservation of natural tooth structure. Modern diagnostic technologies including radiographic imaging, laser fluorescence analysis, and fiber-optic transillumination significantly improve detection of initial and hidden carious lesions. Comparative diagnosis between carious and non-carious lesions such as erosion, abrasion, fluorosis, and wedge-shaped defects allows selection of appropriate therapeutic strategies and prevention of diagnostic errors. Contemporary preventive dentistry and minimally invasive treatment approaches contribute substantially to improved long-term oral health outcomes and reduction of caries-related complications. Dental caries is a progressive multifactorial disease resulting in destruction of hard dental tissues and significant impairment of oral function and quality of life. Early diagnosis and accurate comparative differential evaluation are essential for effective preventive management, minimally invasive intervention, and preservation of healthy tooth structure. Modern diagnostic technologies including radiographic imaging, laser fluorescence analysis, digital assessment, and transillumination methods significantly improve detection of early and hidden lesions while enhancing diagnostic precision. Comparative differentiation between carious and non-carious lesions such as erosion, abrasion, attrition, fluorosis, hypoplasia, and wedge-shaped defects enables selection of appropriate therapeutic strategies and prevents diagnostic errors and unnecessary invasive procedures. Contemporary preventive and minimally invasive dentistry substantially contributes to reduction of disease progression, preservation of oral health, and improvement of long-term functional and aesthetic outcomes.

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