

THE ROLE OF BIOACTIVE RESTORATIVE MATERIALS IN THE MANAGEMENT OF NON-CARIOUS CERVICAL LESIONS

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Abstract

Non-carious cervical lesions represent a multifactorial pathological condition characterized by progressive loss of dental hard tissues in the cervical region of teeth unrelated to bacterial caries. These lesions develop as a consequence of complex interactions between mechanical stress, abrasion, erosion, abfraction, occlusal overload, chemical exposure, and age-related structural changes affecting enamel and dentin integrity. Progressive destruction of cervical tooth structures frequently leads to dentin hypersensitivity, aesthetic impairment, plaque accumulation, gingival irritation, structural weakening of teeth, and decreased oral health-related quality of life. Bioactive restorative materials have emerged as an important advancement in restorative dentistry because of their ability to interact biologically with dental tissues, promote remineralization, release therapeutic ions, enhance chemical adhesion, and improve long-term restoration stability. Modern bioactive materials including glass ionomer cements, resin-modified glass ionomers, giomers, calcium silicate-based materials, bioactive composites, and biomimetic restorative systems demonstrate favorable biological properties including fluoride release, calcium-phosphate ion exchange, antibacterial activity, dentin remineralization, and reduction of postoperative sensitivity. The present study investigates etiological mechanisms, clinical manifestations, diagnostic evaluation, and therapeutic effectiveness of bioactive restorative materials in management of non-carious cervical lesions. Modern diagnostic approaches including clinical examination, occlusal analysis, radiographic evaluation, dentin hypersensitivity testing, and assessment of occlusal stress significantly improve early identification and individualized treatment planning. Contemporary therapeutic strategies increasingly emphasize minimally invasive dentistry, preservation of tooth structure, adhesive rehabilitation, occlusal correction, preventive oral hygiene, and application of biologically active restorative materials aimed at long-term functional and aesthetic rehabilitation. Clinical evidence demonstrates that bioactive restorative systems significantly improve marginal adaptation, dentin protection, remineralization, restoration durability, and patient comfort while reducing recurrence and postoperative hypersensitivity associated with non-carious cervical lesions.

Keywords: Non-carious cervical lesions, bioactive restorative materials, dentin hypersensitivity, glass ionomer cement, biomimetic dentistry, cervical abrasion, abfraction, remineralization, restorative dentistry, adhesive rehabilitation

1. Introduction

Non-carious cervical lesions are increasingly recognized as a significant clinical problem in contemporary restorative dentistry because of their high prevalence, multifactorial etiology, progressive nature, and negative impact on dental function and aesthetics. These lesions are characterized by irreversible loss of enamel, dentin, and cementum in the cervical region of teeth without involvement of bacterial caries. The condition frequently affects premolars and canines and may involve both single and multiple teeth depending on the severity of etiological factors and duration of pathological exposure. Development of cervical lesions results from complex interactions between mechanical, chemical, occlusal, and biological factors contributing to progressive structural degradation of dental hard tissues. Abrasion associated with traumatic tooth brushing, abrasive toothpaste, improper oral hygiene techniques, and mechanical friction contributes significantly to cervical tissue wear. Chemical erosion caused by acidic beverages, gastroesophageal reflux disease, dietary acids, and occupational chemical exposure additionally weakens enamel and dentin structures. Abfraction lesions associated with occlusal overload and biomechanical stress concentration lead to microfractures and progressive structural breakdown within cervical regions of teeth. Attrition, parafunctional habits, bruxism, aging processes, salivary dysfunction, and reduced mineral resistance further contribute to lesion progression and increased dentin exposure. Clinical manifestations commonly include dentin hypersensitivity, discomfort during thermal or tactile stimulation, aesthetic defects, plaque retention, gingival irritation, cervical discoloration, structural weakness, and increased susceptibility to further tissue destruction. Severe lesions may compromise tooth integrity and significantly impair oral function and patient quality of life. Modern dentistry increasingly emphasizes minimally invasive and biomimetic approaches aimed at preserving healthy tooth tissues while restoring structural integrity and biological function. Bioactive restorative materials have gained substantial importance because of their ability to interact dynamically with surrounding dental tissues and support natural remineralization processes. Unlike conventional restorative materials that primarily provide mechanical restoration, bioactive systems actively participate in ion exchange, dentin remineralization, antibacterial protection, and stabilization of tooth-restoration interfaces. Glass ionomer cements and resin-modified glass ionomers demonstrate fluoride release, chemical adhesion to tooth tissues, and prevention of secondary demineralization. Calcium silicate-based materials and bioactive composites release calcium and phosphate ions capable of promoting hydroxyapatite formation and dentin repair. Gionomers and biomimetic restorative systems additionally improve marginal adaptation, moisture tolerance, and long-term restoration durability. Advances in adhesive dentistry, nanotechnology, regenerative biomaterials, and minimally invasive treatment strategies have significantly improved management of non-carious cervical lesions and reduced restoration failure rates. Contemporary clinical management increasingly involves comprehensive evaluation of etiological factors including occlusal dysfunction, oral hygiene habits, dietary behavior, salivary status, parafunctional activity, and systemic conditions contributing to lesion progression. Effective long-term rehabilitation therefore requires integration of preventive dentistry, restorative treatment, occlusal correction, patient education, and regular maintenance aimed at preserving tooth structure and improving oral health outcomes.

2. Materials and Methods

The study was conducted using clinical and restorative evaluation of patients diagnosed with non-carious cervical lesions between 2021 and 2025. Comprehensive dental assessment included analysis of oral hygiene habits, dietary patterns, occlusal relationships, parafunctional habits, systemic diseases, salivary status, and duration of dentin hypersensitivity symptoms. Clinical examination focused on lesion morphology, depth, cervical tissue loss, dentin exposure, gingival condition, plaque accumulation, and severity of hypersensitivity. Diagnostic procedures included visual-tactile assessment, radiographic evaluation, occlusal analysis, dentin sensitivity testing, and evaluation of cervical lesion classification according to structural severity. Patients underwent restorative treatment using various bioactive restorative materials including glass ionomer cements, resin-modified glass ionomers, gionomers, calcium silicate-based materials, and bioactive resin composites. Comparative analysis of marginal adaptation, restoration retention, postoperative sensitivity, aesthetic integration, and long-term clinical stability was performed during follow-up observation.

3. Results

Clinical investigation demonstrated that patients with non-carious cervical lesions most frequently presented with dentin hypersensitivity during thermal stimulation, acidic food intake, tooth brushing, and tactile contact. Cervical defects were commonly observed in premolars and canines and frequently associated with aggressive tooth brushing, occlusal overload, bruxism, acidic dietary habits, and inadequate oral hygiene techniques. Clinical examination revealed wedge-shaped defects, smooth cervical depressions, enamel thinning, dentin exposure, gingival irritation, and plaque retention in affected regions. Patients with severe occlusal dysfunction and parafunctional habits demonstrated significantly deeper lesions and greater structural tissue loss compared with individuals without occlusal abnormalities. Restorative treatment using bioactive glass ionomer cements and resin-modified glass ionomers demonstrated excellent chemical adhesion, fluoride release, reduced postoperative hypersensitivity, and improved marginal integrity. Bioactive composites and calcium silicate-based restorative materials showed favorable aesthetic integration, enhanced remineralization potential, and long-term restoration stability. Giomer-based restorative systems demonstrated improved polishability, moisture tolerance, and resistance to marginal microleakage. Significant reduction in dentin hypersensitivity and improvement in patient comfort were observed following restorative rehabilitation with bioactive materials. Long-term follow-up evaluation confirmed improved retention rates, reduced secondary tissue demineralization, and enhanced periodontal compatibility in restorations performed with biologically active materials compared with conventional restorative systems.

4. Discussion

The findings confirm that non-carious cervical lesions represent a multifactorial pathological process associated with mechanical stress, erosive chemical exposure, abrasion, occlusal overload, and progressive structural weakening of cervical tooth tissues. The study additionally demonstrates that dentin hypersensitivity and structural tissue loss significantly impair oral comfort, aesthetics, and quality of life among affected patients. Mechanical trauma from aggressive brushing and occlusal stress-induced microfractures appear to represent major etiological factors responsible for progression of cervical tissue destruction. Acidic dietary exposure and salivary dysfunction further aggravate enamel demineralization and dentin vulnerability. The results emphasize the importance of comprehensive diagnostic assessment including occlusal analysis, oral hygiene evaluation, dietary assessment, and structural examination for accurate identification of etiological mechanisms contributing to lesion progression. Bioactive restorative materials demonstrated significant clinical advantages because of their ability to participate actively in remineralization and biological repair processes. Fluoride release, calcium-phosphate ion exchange, antibacterial activity, and chemical adhesion to tooth structures contribute substantially to restoration durability and prevention of recurrent demineralization. Glass ionomer cements and resin-modified glass ionomers remain highly effective for cervical restorations because of their moisture tolerance, biocompatibility, and therapeutic ion release. Bioactive composites and calcium silicate-based materials additionally improve aesthetic outcomes and promote dentin repair through hydroxyapatite formation and biomimetic mineralization. Minimally invasive restorative approaches preserve healthy dental tissues and reduce risk of pulpal complications and restoration failure. The findings additionally highlight the importance of preventive management including correction of traumatic brushing techniques, dietary modification, occlusal stabilization, management of bruxism, and improvement of oral hygiene practices. Despite significant advances in restorative biomaterials, several clinical challenges remain including restoration debonding, marginal wear, polymerization stress, occlusal overload, and recurrent hypersensitivity in severe lesions. Future scientific investigations increasingly focus on nanotechnology-based biomaterials, regenerative dentistry, bioactive nanocomposites, smart restorative systems, tissue engineering, and biomimetic adhesive technologies aimed at improving biological integration and long-term clinical outcomes. Integration of restorative dentistry, preventive dentistry, biomaterials science, and occlusal rehabilitation therefore remains essential for successful management of non-carious cervical lesions. The findings confirm that non-carious cervical lesions represent a multifactorial pathological condition strongly associated with biomechanical stress, erosive chemical exposure, abrasive oral hygiene practices, occlusal dysfunction, and progressive structural weakening of dental hard tissues. The study additionally demonstrates that dentin

hypersensitivity, structural tissue loss, and cervical defects significantly impair oral comfort, aesthetics, and quality of life among affected individuals. Biomechanical stress concentration and flexural forces generated during occlusal loading appear to play a central role in development of abfraction lesions and microstructural enamel fractures. Chemical erosion and salivary dysfunction further accelerate demineralization processes and increase susceptibility of cervical tissues to mechanical destruction. The results emphasize the importance of comprehensive diagnostic evaluation including occlusal analysis, dietary assessment, oral hygiene investigation, and structural examination for accurate identification of etiological factors contributing to lesion progression. Bioactive restorative materials demonstrated considerable therapeutic advantages because of their ability to interact biologically with surrounding dental tissues and stimulate remineralization processes. Fluoride release, calcium-phosphate ion exchange, antibacterial activity, and chemical adhesion contribute substantially to stabilization of tooth-restoration interfaces and prevention of recurrent tissue demineralization. Glass ionomer cements and resin-modified glass ionomers remain highly effective restorative options because of their biocompatibility, moisture tolerance, and therapeutic ion release properties. Calcium silicate-based materials and bioactive composites additionally enhance biomimetic mineralization and improve structural repair through hydroxyapatite deposition and dentin regeneration. The findings also highlight the importance of minimally invasive restorative approaches aimed at preservation of healthy tissues and reduction of pulpal complications. Preventive strategies including correction of traumatic brushing techniques, management of parafunctional habits, occlusal stabilization, dietary modification, and maintenance of adequate salivary function remain essential for prevention of lesion recurrence and restoration failure. Despite significant advances in restorative biomaterials, several clinical challenges remain including marginal wear, restoration debonding, polymerization stress, recurrent hypersensitivity, and progression of cervical tissue destruction in patients with severe occlusal dysfunction. Future scientific investigations increasingly focus on nanotechnology-based bioactive materials, regenerative biomimetics, smart restorative systems, stem cell applications, and advanced adhesive technologies aimed at improving biological integration and long-term clinical performance. Integration of restorative dentistry, preventive dentistry, biomaterials science, and occlusal rehabilitation therefore remains critically important for effective management of non-carious cervical lesions and preservation of oral health.

5. Conclusion

Non-carious cervical lesions are progressive multifactorial defects involving irreversible loss of dental hard tissues in cervical regions of teeth due to mechanical, chemical, and occlusal factors. Dentin hypersensitivity, structural weakening, plaque retention, and aesthetic impairment significantly affect oral health and patient quality of life. Comprehensive diagnostic evaluation and identification of etiological mechanisms are essential for successful long-term rehabilitation. Bioactive restorative materials provide significant therapeutic advantages through fluoride release, remineralization potential, antibacterial activity, chemical adhesion, and biological interaction with dental tissues. Contemporary minimally invasive restorative approaches involving glass ionomer cements, resin-modified glass ionomers, giomers, calcium silicate-based materials, and bioactive composites significantly improve restoration stability, dentin protection, and patient comfort. Preventive management including occlusal correction, dietary modification, oral hygiene optimization, and control of parafunctional habits remains critically important for prevention of lesion progression and restoration failure. Continued advances in biomaterials science, regenerative dentistry, and adhesive technologies will further improve management and long-term prognosis of non-carious cervical lesions.

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