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PERIODONTAL HEALTH AND BIOLOGICAL RESPONSES DURING ORTHODONTIC TREATMENT: A NARRATIVE REVIEW OF CLINICAL EVIDENCE AND EMERGING STRATEGIES

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ABSTRACT

Background: Orthodontic tooth movement is facilitated by changes in the periodontal ligament and alveolar bone. During treatment, plaque and calculus accumulation, gingival inflammation, gingival recession, alveolar bone changes, and root resorption may occur and remain causes for concern.

Objective: This review synthesizes evidence concerning periodontal changes, clinical complications, timely interventions, and emerging therapeutic approaches during orthodontic treatment.

Methods: This narrative review was based on review articles and evidence from relevant articles retrieved from academic databases. The articles from past one decade have been studied and reviewed based on orthodontic treatment in patients with periodontal disease and healthy patients.

Results: Orthodontic tooth movement is biomechanical and involves cellular-level remodeling of periodontal tissues, including osteoclast activity. Patients undergoing orthodontic treatment should be screened for periodontal health before treatment. Orthodontic treatment and periodontal maintenance require an interdisciplinary approach. Limited evidence suggests that orthodontic treatment may improve periodontal conditions in periodontally compromised individuals when periodontal disease is controlled. Gingival recession and root resorption are multifactorial; some studies report better periodontal parameters with clear aligners, although clear aligners have not been proven universally superior.

Conclusion: Orthodontic treatment requires meticulous planning based on the patient's age, systemic health, alveolar bone condition, periodontal status, oral hygiene, and long-term maintenance needs.

Keywords: orthodontic tooth movement; periodontal health; periodontitis; periodontal ligament; clear aligners; gingival recession; oral microbiome; alveolar bone remodeling; root resorption.

INTRODUCTION

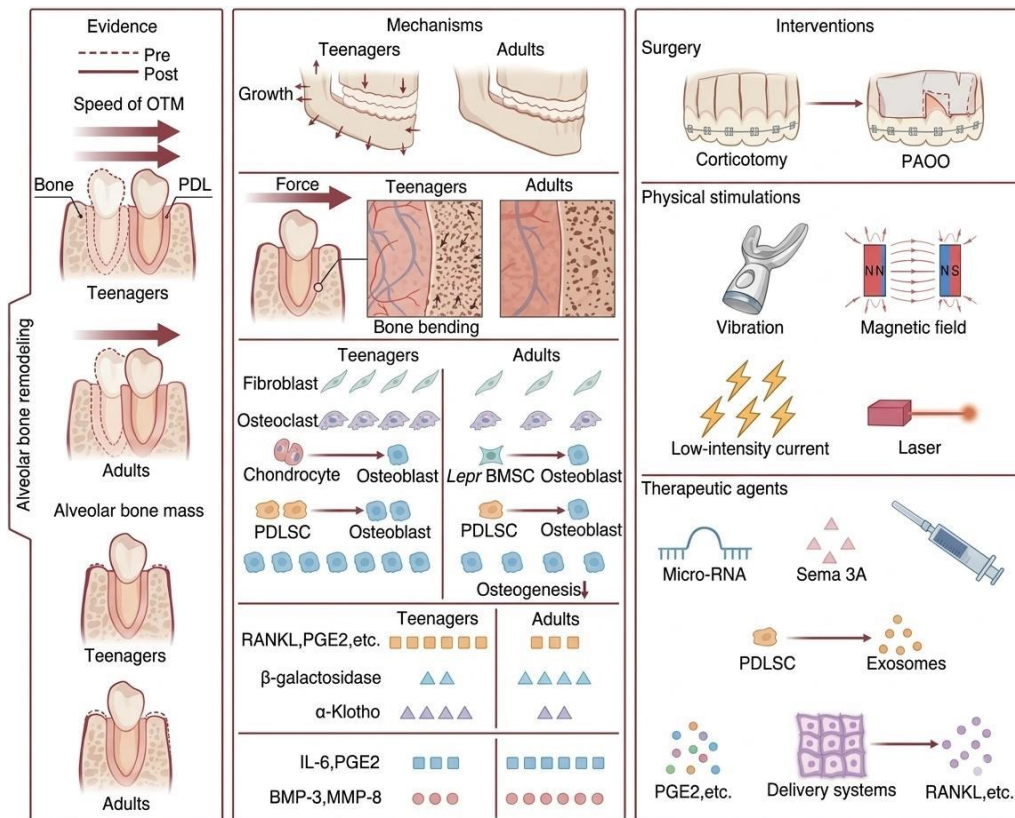
Orthodontic treatment depends largely on the condition of the periodontal tissues and their ability to withstand the mechanical forces applied during treatment. The continuous application of force produces periodontal changes, including ligament deformation, cellular alterations, inflammation of the supporting tissues, and bone remodeling. Therefore, orthodontic tooth movement is not merely mechanical; it is a complex biomechanical process.[1,2]

The periodontal ligament and osteocytes detect mechanical forces during treatment and regulate osteoclast and osteoblast activity. The inflammatory response to orthodontic force is controlled, whereas periodontitis generally involves microbial dysbiosis and a dysregulated host response.[2,3] This distinction has important clinical implications. Before elective tooth movement is initiated, any active inflammation in periodontally compromised individuals should be treated. Patients with compromised periodontal health may have underlying bone loss, loss of gingival attachment, gingival recession, or tooth mobility and may require prompt attention and appropriate restorative treatment. These factors require individualized planning and interdisciplinary monitoring.[4,5,11]

EVIDENCE SYNTHESIS

Biological Mechanisms

Orthodontic force generates compressive and tensile forces within the periodontium. These forces activate osteocytes and osteoclasts, which in turn regulate intracellular cytokines, chemokines, and the RANK/RANKL/OPG axis. This process regulates immune-cell recruitment and osteoclast differentiation on the pressure side, leading to tissue reorganization and osteoblast-mediated bone formation. [1–3]



Periodontal Disease and Interdisciplinary Care

Orthodontic treatment may be beneficial for patients with a history of periodontitis when carefully planned. The treatment objectives should be clearly defined in accordance with the existing bone support and periodontal health. When periodontal and orthodontic treatments are coordinated, they may improve function and aesthetics, facilitate healthier tooth positioning, and potentially reduce plaque accumulation. However, evidence for improvements in gingival attachment, pocket depth, or marginal bone height remains limited and of low certainty.[4,6] Orthodontic treatment alone cannot be considered a treatment for periodontal disease. Regular follow-up, periodic professional prophylaxis, and infection-control measures are essential. Treatment should be postponed when active inflammation is present and cannot be controlled. [4,6]

Appliances, Oral Hygiene, Microbiome, and Caries

Compared with fixed appliances, clear aligners may facilitate oral-hygiene maintenance because they are removable. However, aligner surfaces can also accumulate biofilm. Comparative studies vary in design, follow-up duration, appliance protocols, and patient compliance; therefore, the available evidence does not establish that clear aligners are universally superior in periodontal performance. [7,8]

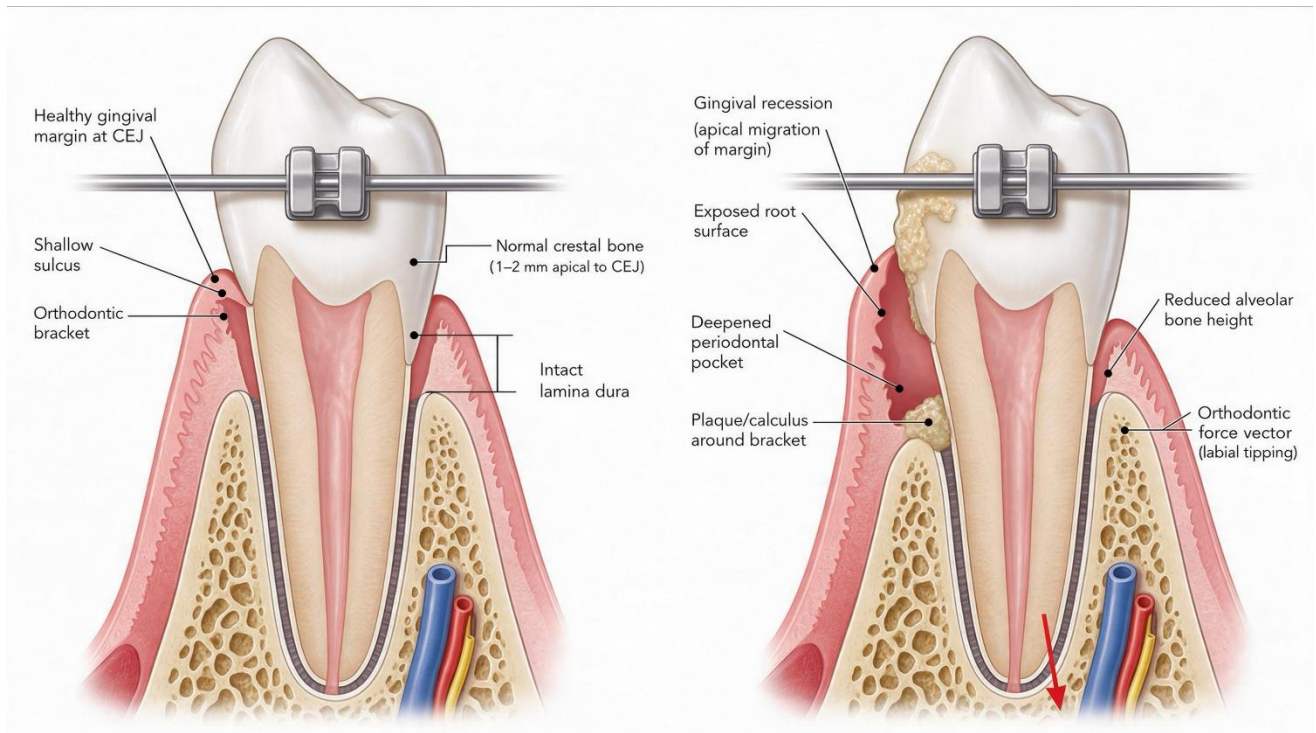
Orthodontic treatment is usually a long-term process and may produce changes in the underlying bone and periodontium. It may also alter the oral microbial flora. Preventive measures, including fluoride treatment when indicated, periodic dental follow-up, and appropriate oral-hygiene practices, may help reduce the risk of periodontal disease and dental caries. [9,10]

Gingival Recession, Bone Response, and Root Resorption

Multiple factors contribute to gingival recession, bone loss, and root resorption. These include the individual's oral-hygiene status, the health of the alveolar bone and periodontal tissues, tooth position, and dental arrangement, including crowding or spacing. Long-term monitoring

is important because gingival recession may become more apparent during the retention phase.[8,11]

Age may influence the pattern of the orthodontic response because bone remodeling becomes slower with advancing age, which may affect tooth movement. Age alone is not a contraindication to orthodontic treatment; however, appropriate force application and realistic expectations are important.[12]



Although root resorption is multifactorial, its risk may be reduced through controlled force application, avoidance of unnecessarily prolonged treatment, and assessment of root and bone conditions using pre-treatment radiographs.[2]

Preventive and Emerging Strategies

Preventive care should begin before appliance placement and continue throughout treatment and retention. It should include periodic periodontal assessment, individualized oral-hygiene instruction, and prompt treatment of any active periodontal disease or other oral condition. Photobiomodulation has a plausible biological rationale and encouraging experimental findings; however, clinical protocols remain heterogeneous, and evidence supporting routine clinical adoption is limited.[12] Studies investigating cell-immune interactions under orthodontic force are promising but do not yet provide definitive clinical evidence.[13] Regenerative biomaterials, including hydrogel-based systems, remain primarily preclinical and should not be presented as established treatments.[14]

DISCUSSION

The evidence supports a periodontally driven orthodontic pathway. Orthodontic movement occurs through controlled tissue remodeling, whereas periodontal disease requires management of microbial dysbiosis and host inflammation. Although both processes involve inflammatory and osteoimmune pathways, periodontal stability should precede active tooth movement.[3,4] There is no evidence that orthodontic treatment should be categorically avoided in patients with a history of periodontal disease. The decision should depend on prior assessment of periodontal health, underlying bone support, patient compliance with oral-hygiene maintenance, and the

ability to attend regular follow-up appointments. Conversely, healthy periodontal tissues do not eliminate the risks of gingival recession, root resorption, or loss of bone support. Comparisons between clear aligners and fixed appliances should be interpreted cautiously because any apparent health benefit may reflect removability, hygiene behavior, case selection, or patient compliance rather than appliance design alone. Emerging biological interventions should remain within research settings until standardized clinical protocols and long-term outcomes are available.

LIMITATIONS

This narrative review is limited because it synthesizes evidence from 14 peer-reviewed articles. No formal risk-of-bias assessment or quantitative synthesis was performed. The evidence is heterogeneous and includes reviews, consensus guidance, clinical studies, mechanistic investigations, and preclinical research. Findings from mechanistic and preclinical studies should not be interpreted as proof of clinical effectiveness.

CONCLUSION

Periodontal tissues are active biological participants in orthodontic treatment. Orthodontic force produces coordinated biomechanical, inflammatory, immunocellular, and skeletal responses that result in tooth movement. Patients with treated and controlled periodontal conditions may be considered for orthodontic treatment with meticulous planning and long-term maintenance. Clear aligners have not been universally proven to be periodontally superior, while gingival recession and root resorption require individualized risk assessment. Photobiomodulation, multi-omics, and regenerative approaches are promising but remain under investigation, with no clear evidence supporting routine clinical use. Prevention, proper oral hygiene, periodontal disease control, conservative biomechanics, and long-term follow-up should remain the foundations of care.

Tables

Table 1. Clinical risk factors and management principles

Risk factor	Potential concern	Management principle
Thin periodontal support	Recession or loss of attachment	Assess before treatment and monitor
Reduced alveolar support	Biomechanical vulnerability	Use conservative tooth movement
Active inflammation	Unfavorable tissue environment	Stabilize periodontal disease first
Poor plaque control	Gingivitis, caries, or white spot lesions	Use intensive preventive care
Excessive or prolonged force	Root resorption or supporting tissue injury	Individualize mechanics and duration
Advanced age	Slowed or altered bone remodeling	Set realistic objectives and monitor
Poor retention or maintenance	Late positional or periodontal changes	Continue long-term follow-up

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