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Original Article

Orthodontic Tooth Movement in the Periodontally Compromised Patient: A Narrative Review

Li Wei[1], Javier L. Moreno[1]*, Tesfaye M. Bekele[1]

[1]Department of Periodontics and Orthodontics, School of Stomatology, Peking University, Beijing, China.

***E-mail** ✉ javier.moreno@outlook.com

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ABSTRACT

Orthodontic tooth movement (OTM) in patients with periodontal compromise presents unique challenges due to altered biomechanics and increased risk of further tissue damage. This narrative review critically synthesizes existing clinical, biological, and experimental evidence on OTM in periodontally compromised patients, highlighting consensus on interdisciplinary approaches, controversies regarding treatment timing and specific movements, and clinical implications. Literature from 1990 to November 2025, including systematic reviews, consensus statements, retrospective studies, and bibliometric analyses, was evaluated. Key findings indicate that OTM is feasible and beneficial following periodontal stabilization, with regenerative therapies enhancing outcomes. Consensus exists on the necessity of inflammation control prior to orthodontics, use of light forces (5-15 g), and multidisciplinary collaboration to improve probing depths, clinical attachment levels, function, and aesthetics. Controversies persist on the optimal timing of OTM post-regeneration (early vs. late) and the safety of movements like intrusion in severe defects, with some evidence suggesting early intervention may not compromise healing and could enhance efficiency. Biological evidence underscores shifts in the center of resistance apically, necessitating adapted mechanics to minimize root resorption and attachment loss. Experimental data from animal models reveal similar RANKL/OPG-mediated bone remodeling in compromised vs. healthy tissues. Knowledge gaps include long-term stability in stage IV periodontitis and patient-reported outcomes. This review underscores evidence-driven strategies for safe OTM, emphasizing conservative management to optimize periodontal health.

Keywords: Orthodontic tooth movement, Periodontitis, Periodontal regeneration, Interdisciplinary treatment, Biomechanics, Clinical outcomes, Tissue remodeling

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Introduction

Periodontal disease, encompassing gingivitis and periodontitis, remains one of the most prevalent chronic inflammatory conditions affecting the supporting structures of the teeth, including the gingiva, periodontal ligament (PDL), cementum, and alveolar bone. According to global epidemiological data, severe periodontitis affects approximately 19% of adults aged 35-44 years and up to 51% in those over 65, contributing significantly to tooth loss and diminished quality of life [1,2]. The 2017 World Workshop classification delineates periodontitis into stages I-IV based on severity, complexity, and extent, with stage IV characterized by advanced bone loss, masticatory dysfunction, and secondary occlusal trauma often manifesting as pathologic tooth migration, flaring, or extrusion [3]. In such patients, orthodontic intervention is increasingly sought not only for aesthetic correction but also as an adjunct to restore function and facilitate periodontal maintenance.

The interplay between orthodontics and periodontology is bidirectional. On one hand,

malocclusion can exacerbate periodontal disease by promoting plaque accumulation, occlusal trauma, and uneven force distribution, leading to deepened pockets and attachment loss [4]. Conversely, periodontal compromise alters the biological response to orthodontic forces, as reduced alveolar bone support shifts the center of tooth resistance apically, increasing susceptibility to tipping, root resorption, and further bone dehiscence [5]. Despite these challenges, evidence suggests that controlled OTM can benefit periodontally compromised patients by realigning teeth, closing diastemata, and improving occlusal relationships, thereby enhancing hygiene and distributing masticatory loads more evenly [6].

Historically, orthodontic treatment in adults with periodontitis was approached cautiously due to fears of accelerating disease progression. Early studies in the 1980s and 1990s demonstrated that untreated inflammation during OTM could lead to irreversible attachment loss, prompting guidelines for mandatory periodontal stabilization prior to orthodontics [7]. Advances in regenerative techniques, such as guided tissue regeneration (GTR), enamel matrix derivatives (EMD), and bone grafts, have since expanded therapeutic possibilities, allowing for defect repair and subsequent tooth movement [8]. Recent consensus statements emphasize an interdisciplinary framework, where periodontists and orthodontists collaborate on diagnosis, treatment sequencing, and maintenance to mitigate risks [9].

The rationale for this narrative review stems from the growing demand for adult orthodontics, driven by aesthetic ideals and technological innovations like clear aligners and temporary anchorage devices (TADs) [10]. While systematic reviews have addressed specific aspects, such as OTM effects on probing depths or attachment levels, a comprehensive synthesis integrating biological mechanisms, clinical evidence, and controversies is lacking [11]. This review focuses on narrative and critical evaluation rather than meta-analysis, given the heterogeneity of studies, which often include small samples, varied methodologies, and short follow-ups. The aim is to critically appraise published evidence on OTM in periodontally compromised patients, highlighting areas of consensus (e.g., prerequisite inflammation control), controversies (e.g., intrusion safety in deep defects), and implications for practice.

Biologically, OTM relies on the PDL's mechanotransduction, where applied forces induce compression and tension zones, triggering osteoclastogenesis via RANKL/OPG pathways and osteoblast activity for remodeling [12]. In compromised periodontium, reduced bone density and altered PDL vascularity may amplify inflammatory responses, potentially leading to hyalinization and delayed movement [13]. Experimental animal models, such as ligature-induced periodontitis in rats, have shown that OTM elicits similar RANKL upregulation in diseased tissues, but with heightened OPG expression potentially modulating resorption [14]. Clinically, this translates to the need for light, continuous forces to avoid ischemia and promote repair.

Epidemiologically, the prevalence of orthodontic needs in periodontal patients is notable; cross-sectional studies report that up to 40% of stage III-IV periodontitis cases exhibit secondary malocclusion requiring correction [15]. Treatment outcomes vary: retrospective analyses indicate probing depth reductions of 2-4 mm and attachment gains of 1-3 mm post-interdisciplinary therapy, but relapse risks persist without lifelong retention [6]. Controversies arise in timing—whether OTM should commence early (1-3 months post-regeneration) to leverage healing dynamics or late (6-12 months) to ensure stability [16]. Additionally, debates surround appliance choice: fixed appliances may hinder hygiene, while aligners offer removability but limited control in mobile teeth [17].

This review draws from diverse sources, including randomized controlled trials (RCTs), intervention studies, and expert consensuses up to November 2025, sourced from databases like PubMed and Web of Science. Inclusion prioritized human studies with verifiable periodontal and orthodontic metrics, excluding animal-only or case reports unless providing mechanistic insights. The structure proceeds with a thematic literature review synthesizing evidence on biological foundations, pre-treatment strategies, biomechanical adaptations, and specific movements. Subsequent sections (in Part 2) will address clinical implications, knowledge gaps, and conclusions.

In summary, while OTM in periodontally compromised patients is evidence-supported when inflammation-free, success hinges on tailored biomechanics and vigilant monitoring. This review provides a conservative, clinically grounded synthesis to guide practitioners in navigating this complex interface [18-20].

Thematic Literature Review

Orthodontic tooth movement (OTM) is fundamentally driven by mechanically induced remodeling of the periodontal ligament (PDL) and adjacent alveolar bone. Application of orthodontic force creates distinct zones of compression and tension within the PDL,

initiating a cascade of cellular and molecular responses that regulate bone resorption and apposition. In a healthy periodontium, compressive forces stimulate periodontal ligament fibroblasts, osteoblast-lineage cells, and immune cells to upregulate receptor activator of nuclear factor kappa-B ligand (RANKL), which binds to its receptor (RANK) on osteoclast precursors and promotes their differentiation and activation. This results in localized bone resorption on the pressure side, allowing tooth displacement. Conversely, on the tension side, osteoblast recruitment and activity are favored, with osteoprotegerin (OPG) acting as a decoy receptor that inhibits RANKL, thereby limiting osteoclastogenesis and supporting new bone formation [21].

In periodontally compromised patients, this tightly regulated balance is altered by the presence of chronic inflammation. Persistent periodontal inflammation is associated with elevated levels of pro-inflammatory cytokines such as interleukin-1β (IL-1β), tumor necrosis factor-alpha (TNF-α), and prostaglandin E2, which enhance RANKL expression and suppress OPG activity. This inflammatory milieu amplifies osteoclastogenesis and accelerates alveolar bone resorption, increasing the risk that orthodontic forces may exacerbate attachment loss if applied in the presence of active disease [22]. Additionally, vascular alterations and fibrosis within the inflamed PDL may impair cellular turnover and delay normal remodeling responses, rendering the tissues more susceptible to ischemia and hyalinization under excessive force [23-29].

Experimental animal models have provided valuable insight into the biological behavior of compromised periodontal tissues under orthodontic loading. A 2025 rat model of ligature-induced periodontitis demonstrated that, following resolution of active inflammation, orthodontic force application resulted in RANKL/OPG expression patterns comparable to those observed in periodontally healthy controls, with no significant differences in PDL width or overall bone metabolic activity [14]. These findings suggest that the compromised periodontium retains a substantial capacity for adaptive remodeling once inflammatory burden is controlled. Notably, the same study reported increased OPG expression on non-diseased sides at 14 days post-force activation, which may reflect compensatory or protective mechanisms aimed at limiting excessive resorption in vulnerable regions [14].

Human histological evidence, although limited due to ethical and methodological constraints, supports these experimental observations. Biopsies obtained from patients with stage III periodontitis undergoing orthodontic treatment have revealed more extensive zones of hyalinization during the early phases of force application, consistent with reduced periodontal support and altered stress distribution. Importantly, these hyalinized areas were followed by normal reparative remodeling when light and continuous forces were used, indicating that tissue recovery remains possible despite initial delays [14]. Collectively, these biological findings reinforce the concept that orthodontic tooth movement in the compromised periodontium is not inherently destructive, but highly dependent on inflammation control, force magnitude, and the adaptive capacity of periodontal tissues.

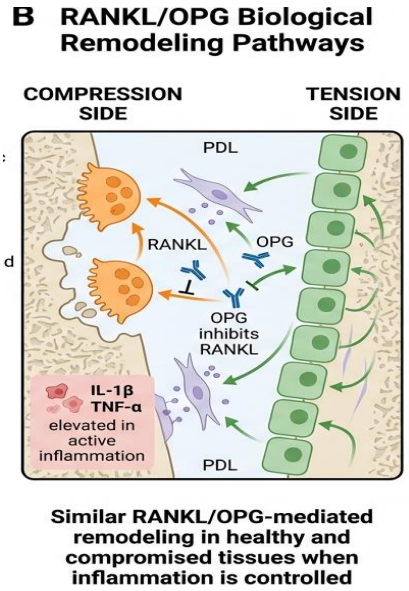

Figure 1. Biological remodeling pathways

Critically, reduced periodontal support shifts the tooth's center of resistance apically by 1-2 mm per 50% bone loss, increasing moment-to-force ratios and tipping tendencies [5]. This necessitates biomechanical adjustments to prevent dehiscence or fenestration. Consensus from bibliometric analyses highlights emerging trends in microbiome modulation and regenerative adjuncts, where dysbiosis during OTM correlates with attachment loss, underscoring the need for pre-treatment microbial profiling [4].

Periodontal stabilization is a fundamental prerequisite for the safe initiation of orthodontic tooth movement (OTM), as the application of orthodontic forces in the presence of active periodontal inflammation is associated with an increased risk of irreversible attachment loss and accelerated bone resorption. Current evidence and clinical guidelines emphasize that orthodontic therapy should only be considered once periodontal disease has been brought under

control and tissue homeostasis has been re-established. The European Federation of Periodontology (EFP) S3 clinical practice guidelines recommend comprehensive non-surgical periodontal therapy, including scaling and root planing combined with individualized oral hygiene instruction, as the first-line approach. This phase is followed by a structured re-evaluation to assess probing depths, bleeding on probing (BOP), and patient compliance. For residual infrabony defects measuring ≥3 mm, regenerative surgical interventions, such as guided tissue regeneration (GTR), enamel matrix derivatives (EMD), or bone grafting procedures, are advised to restore periodontal support prior to orthodontic intervention [30].

More stringent criteria for orthodontic readiness have been proposed in recent expert consensus statements. A 2025 interdisciplinary consensus report stipulates that orthodontic treatment should not commence in sites exhibiting probing depths ≥5 mm with BOP or ≥6 mm in the absence of BOP, reflecting an effort to minimize the risk of disease reactivation under orthodontic loading [9]. These thresholds highlight the importance of both inflammatory control and structural stability, recognizing that deep but non-inflamed pockets may still pose biomechanical challenges.

The optimal timing of orthodontic force application following periodontal therapy remains one of the most debated issues in interdisciplinary care. Traditionally, late initiation of orthodontics—typically 6 to 12 months after regenerative surgery—has been advocated to allow for soft tissue maturation and mineralization of newly formed bone. Retrospective studies supporting this approach report favorable outcomes, including probing depth reductions of approximately 2.5–3.5 mm and clinical attachment level (CAL) gains of 1.5–2.5 mm, with low rates of complication when forces are applied conservatively [31]. This delayed protocol is often perceived as safer, particularly in patients with advanced bone loss or multiple risk factors.

In contrast, emerging evidence suggests that earlier orthodontic intervention, initiated within 1 to 3 months following periodontal surgery, may be equally safe and potentially more efficient. A 2022 retrospective analysis involving 41 infrabony defects demonstrated greater mean PD reduction (3.2 mm) and CAL gain (2.1 mm) in patients treated with early OTM compared to those undergoing delayed orthodontics [6]. These findings are frequently attributed to exploitation of the regional acceleratory phenomenon (RAP), a transient phase of increased bone turnover and reduced resistance to tooth movement following surgical trauma. Importantly, no adverse effects on periodontal healing or attachment stability were reported in this cohort, provided inflammation was controlled and light forces were applied [32-40].

Comparative analyses across different periodontal treatment modalities indicate no consistent superiority of one regenerative approach over another in terms of orthodontic outcomes. Studies comparing GTR, EMD, and open-flap debridement have generally reported similar periodontal improvements prior to and during orthodontic therapy, although substantial heterogeneity in study design, defect morphology, and follow-up duration limits definitive conclusions [11]. As a result, treatment sequencing should be individualized, taking into account defect characteristics, patient-related risk factors, and clinician expertise rather than adherence to a rigid timeline [41-51].

There is broad consensus on the necessity of close interdisciplinary collaboration throughout all phases of treatment. Joint case planning and periodic reassessment by both periodontists and orthodontists facilitate early detection of inflammation recurrence and allow for timely modification of mechanics or hygiene protocols. Risk assessment is particularly critical in patients with known modifiers of periodontal healing, such as smoking, poorly controlled diabetes, or a history of aggressive periodontitis [52]. Once orthodontic treatment has commenced, supportive periodontal therapy at 3- to 6-month intervals is strongly recommended. This is especially important in patients wearing fixed appliances, as plaque accumulation and gingival inflammation have been shown to increase by approximately 20–30% during active orthodontic treatment [53]. Regular maintenance and patient education therefore remain central to preserving periodontal stability and ensuring the long-term success of interdisciplinary care [54-64].

Biomechanical Considerations and Orthodontic Techniques

Altered biomechanics demand light forces (5-15 g/tooth) to minimize ischemia in thinned PDL [9]. Segmented arches and TADs provide controlled moments, reducing extrusion risks in low-support areas [65]. Clear aligners are preferred for hygiene but critiqued for insufficient torque in mobile teeth; a 2023 review notes better periodontal indices with aligners vs. fixed appliances in mild cases [5].

Accelerated techniques like piezocision or micro-osteoperforations (MOPs) exploit RAP to shorten treatment by 30-50%, with evidence of preserved attachment in compromised patients [66]. However, controversies arise in severe cases, where MOPs may risk further bone loss if not inflammation-free [67].

Low-level laser therapy (LLLT) adjunctively reduces pain and enhances regeneration, improving CAL by 0.5-1 mm [68].

Effects of Specific Tooth Movements

Intrusion in deep defects is debated: light forces (10-15 g) can reduce crown height and shallow pockets, but risks root resorption if furcations are involved [11]. A systematic review reports CAL gains of 1-2 mm without progression, yet long-term data are sparse [11]. Extrusion effectively increases bone height (1-3 mm) for implant sites, with consensus on progressive application (<2 mm/month) [69].

Uprighting tilted molars fills infrabony defects, reducing PD by 2-4 mm, but off-defect movements yield less improvement [6]. Into-defect OTM benefits most, as teeth "carry" bone, improving architecture [70]. Alignment corrects pathologic migration, enhancing aesthetics, but requires fixed retention to prevent relapse [71].

Outcomes and Stability

Integrated treatment yields PD reductions (2-4 mm), CAL gains (1-3 mm), and improved patient satisfaction, with no negative impact in stable cases [1]. Long-term stability (10+ years) is achievable with recall, though 20-30% relapse in stage IV [72]. Controversies include adolescent vs. adult responses, with limited evidence in youth [73].

Critically, study limitations—small cohorts, short follow-ups, bias—temper enthusiasm. While consensus supports feasibility, evidence quality is moderate-low, necessitating cautious extrapolation.

Clinical Implications

The synthesis of evidence underscores several practical considerations for clinicians managing orthodontic tooth movement (OTM) in periodontally compromised patients. Foremost, interdisciplinary collaboration between periodontists and orthodontists is essential, as highlighted by consensus guidelines [9,30]. This involves joint diagnostic assessments, including radiographic evaluation of bone loss and clinical measurements of probing depths (PD) and clinical attachment levels (CAL), to stratify risk according to the 2017 periodontitis staging [3]. Pre-orthodontic periodontal therapy should achieve disease stability, defined as PD ≤4 mm without bleeding on probing (BOP) or PD ≤5 mm with BOP resolution [30]. Non-surgical scaling and root planing, supplemented by adjunctive antimicrobials if needed, forms the foundation, with regenerative procedures (e.g., GTR, EMD) reserved for infrabony defects to restore support [8,31].

Biomechanically, adapted force systems are critical to mitigate risks in reduced periodontium. Light forces (5-15 g) minimize hyalinization and root resorption, particularly in apically shifted centers of resistance [5,65]. Temporary anchorage devices (TADs) enable precise control, facilitating intrusion or extrusion without reciprocal effects on adjacent teeth [65, 69]. For instance, in stage IV periodontitis with pathologic migration, uprighting molars or intruding incisors can reduce PD by 2-4 mm, improving hygiene and function [6, 11]. Appliance selection should prioritize patient compliance; clear aligners reduce plaque accumulation compared to fixed appliances, though they may require hybrid approaches for complex movements [17,53].

Timing of OTM post-regeneration influences efficiency. While late intervention (6-12 months) ensures maturation, early OTM (1-3 months) may exploit the regional acceleratory phenomenon (RAP) for faster remodeling without compromising outcomes [6,16]. Clinicians should monitor for inflammation flares, incorporating 3-monthly periodontal maintenance to maintain gingival health [24,25]. Adjuncts like low-level laser therapy (LLLT) can enhance CAL gains and reduce discomfort, particularly in adults [29].

Patient-specific factors warrant tailoring: smokers or diabetics require intensified monitoring due to impaired healing [52]. Outcomes emphasize functional restoration—improved mastication and aesthetics—while preserving attachment [1,6]. Retention is lifelong, with fixed lingual wires or vacuum-formed retainers to prevent relapse in mobile teeth [71,72]. Overall, evidence supports OTM as a viable adjunct, provided inflammation is controlled, forces are conservative, and follow-up is rigorous, potentially averting tooth loss and enhancing quality of life.

Knowledge Gaps

Despite accumulated evidence, several lacunae persist in the literature on OTM in periodontally compromised patients. Long-term stability (>10 years) remains understudied, particularly in stage IV periodontitis, where relapse rates of 20-30% are reported but lack prospective validation [72]. Most studies feature short follow-ups (1-5 years) and small cohorts, limiting generalizability [11,73]. Patient-reported outcomes, such as satisfaction with aesthetics or function, are infrequently assessed, with reliance on clinician-measured metrics like PD and CAL [6].

Controversies in timing and movement types highlight gaps: comparative RCTs on early versus late OTM post-regeneration are scarce, with retrospective data showing trends but no definitive superiority [6,16]. The safety of intrusion in furcation-involved teeth or severe horizontal bone loss lacks robust evidence, as histological studies are ethical constraints in humans [11, 14]. Biomechanical modeling in compromised tissues is rudimentary, with finite element analyses often based on healthy assumptions, overlooking variable bone density [5,13].

Biological mechanisms require deeper exploration; while RANKL/OPG pathways are implicated, microbiome shifts during OTM in diseased states are underexplored, potentially linking to recurrence [4,22]. Adjunct therapies like MOPs or LLLT show promise but need standardization and long-term trials in periodontal cohorts [66, 68]. Demographic gaps include adolescents with aggressive periodontitis or underrepresented groups (e.g., elderly, comorbidities), where evidence is anecdotal [73].

Methodological issues compound these gaps: heterogeneity in defect classification, force magnitudes, and outcome reporting hampers meta-analyses [11]. Future research should prioritize multicenter RCTs with standardized protocols, incorporating cone-beam CT for 3D bone assessment and patient-centered endpoints to bridge these voids.

Conclusion

This narrative review critically integrates clinical, biological, and experimental evidence on orthodontic tooth movement in periodontally compromised patients. Consensus affirms the feasibility of OTM following periodontal stabilization, with benefits in PD reduction, CAL gain, and functional-aesthetic improvements, provided interdisciplinary approaches and conservative biomechanics are employed. Controversies in treatment timing and specific movements underscore the need for individualized planning. While biological resilience in compromised tissues is evident, clinical implications emphasize inflammation control and vigilant maintenance. Addressing knowledge gaps through rigorous, long-term studies will refine protocols, enhancing outcomes in this growing patient demographic.

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