Asian Journal of Periodontics and Orthodontics
2026, Volume 6, Issue 1, Page No: 136-146
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Available online at: www.tsdp.net

ISSN: 3062-3499

Original Article

Reframing Orthodontic Force Prescription in the Reduced Periodontium: A Theoretical Analysis of Attachment Geometry, Centers of Resistance, and the Limits of Conventional Biomechanical Assumptions

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Received 17 July 2026; **Revised:** 20 August 2026; **Accepted:** 25August 2026

ABSTRACT

Orthodontic force prescription is commonly discussed through nominal force magnitude, moment-to-force characteristics, appliance configuration, and intended tooth movement. These concepts remain necessary but become incomplete when periodontal attachment has been substantially reduced. Loss of supporting tissue changes the geometry through which orthodontic loads are transmitted, alters the relationship between the tooth and its center of resistance, and may concentrate periodontal ligament loading even when an external appliance setting is unchanged. This theoretical biomechanical analysis examines how conventional assumptions about orthodontic force systems should be reinterpreted in a stable reduced periodontium. The analysis distinguishes periodontal inflammatory control from residual support geometry, reviews the mechanical foundations of tooth movement, and evaluates how attachment loss modifies resistance geometry and load distribution. The central proposition is that an orthodontic force should not be interpreted as an invariant biological dose independent of the support state of the tooth. Instead, force magnitude, line of action, moment generation, attachment geometry, periodontal ligament response, and treatment stage should be considered jointly. Existing clinical evidence supports the feasibility of orthodontic treatment in carefully stabilized periodontal patients, but it does not establish universal force-reduction thresholds for reduced support. Likewise, finite element models provide valuable mechanistic insight but cannot be converted directly into validated patient-specific prescriptions. A support-dependent interpretation of orthodontic biomechanics is therefore warranted, provided that simulated mechanical behavior, clinical evidence, and theoretical inference remain explicitly separated.

Keywords: Reduced periodontium, Orthodontic biomechanics, Center of resistance, Periodontal attachment loss, Periodontal ligament, Orthodontic force systems

How to Cite This Article: Weber J, Brenner M. Reframing Orthodontic Force Prescription in the Reduced Periodontium: A Theoretical Analysis of Attachment Geometry, Centers of Resistance, and the Limits of Conventional Biomechanical Assumptions. Asian J Periodont Orthodont. 2026;6(1):136-146. https://doi.org/10.51847/sfuEkKj1w6

Introduction

A reduced periodontium is not synonymous with uncontrolled periodontal disease. Contemporary periodontal classification distinguishes health on an intact periodontium from health on a reduced periodontium, including the stable condition that may follow successful treatment of periodontitis [1]. The staging framework for periodontitis similarly recognizes that attachment and bone loss can produce lasting functional and anatomical complexity even after inflammatory control has been achieved [2]. This distinction is central to orthodontic reasoning because diagnostic stability does not restore the architecture that existed before tissue loss. A tooth may therefore be periodontally stable while remaining mechanically different from a comparable tooth with intact supporting tissues. The current classification system provides the terminology necessary to separate disease status from residual structural support rather than treating them as interchangeable concepts [3].

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This separation becomes particularly important in patients with advanced periodontal destruction. Stage IV periodontitis may involve pathological migration, tooth mobility, loss of posterior support, occlusal dysfunction, and the need for multidisciplinary rehabilitation. The European Federation of Periodontology guideline places orthodontic treatment within an interdisciplinary sequence in appropriately selected patients after periodontal control, rather than defining reduced periodontal support as an automatic contraindication [4]. That position changes the relevant biomechanical question. The issue is no longer simply whether a periodontally compromised tooth can be moved. It is whether the conventional mechanical assumptions used to prescribe and interpret orthodontic forces remain valid when attachment geometry, periodontal ligament area, and alveolar support have changed.

Clinical syntheses support a cautiously permissive rather than categorical view. Orthodontic treatment in adequately treated periodontal patients has not consistently produced deterioration in probing or attachment outcomes, although the available evidence remains heterogeneous and frequently at risk of bias [5]. Combined periodontal-orthodontic therapy can also improve pathological tooth migration and related functional problems in patients with severe periodontal breakdown [6]. Evidence from teeth with intrabony defects or complex molar positions similarly suggests that carefully sequenced orthodontic movement may be incorporated into interdisciplinary management, but the evidence base is uneven and does not justify assuming equivalent mechanical tolerance across all reduced-support configurations [7]. A broader systematic review of orthodontic treatment in periodontally compromised patients reached a similar conclusion: successful treatment appears possible, but controlled biomechanics and close periodontal management are essential, while methodological heterogeneity prevents strong quantitative prescription rules [8].

Clinical studies reinforce this boundary. In a prospective randomized study of stabilized periodontitis, orthodontic treatment did not produce significant worsening of key periodontal parameters compared with periodontal maintenance alone under the conditions examined [9]. Long-term observational evidence also indicates that regenerative periodontal treatment followed by orthodontic tooth movement can remain stable over many years in selected, compliant patients [10]. At the same time, periodontal phenotype and soft- and hard-tissue conditions remain relevant to risk assessment before orthodontic movement [11]. Together, these findings argue against two opposing simplifications: that reduced periodontal support necessarily prohibits orthodontic movement, and that periodontal stabilization makes the mechanics equivalent to those of an intact periodontium.

The present analysis addresses the second error. Conventional orthodontic terminology often gives the impression that a prescribed force or moment carries a relatively stable mechanical meaning. In practice, the external load generated by an appliance interacts with root morphology, periodontal ligament geometry, alveolar support height, force application point, moment arm, anchorage, treatment stage, and biological response. Attachment loss modifies several of these variables at once. A nominally identical load can therefore produce a different pattern of tooth displacement, center-of-rotation behavior, periodontal ligament stress, and tissue response after support has been reduced.

The purpose of this article is to develop a theoretical biomechanical account of that problem without converting model-based findings into unvalidated clinical thresholds. The analysis first establishes the mechanical and biological foundations required to interpret orthodontic loading, then examines how periodontal attachment loss changes those foundations. Subsequent sections reconstruct force-prescription logic for common tooth movements and develop a support-dependent interpretation framework that distinguishes clinically supported principles from biomechanical inference. The underlying proposition is deliberately conditional: reduced periodontal support should alter how orthodontic forces are interpreted, but current evidence does not justify a universal numerical rule for how much every force should be reduced.

Mechanical foundations of tooth movement

Orthodontic tooth movement begins with an externally generated force system, but the resulting biological process is mediated through the periodontal ligament, alveolar bone, vascular responses, cellular mechanotransduction, and time-dependent remodeling. Contemporary mechanobiological evidence emphasizes that the periodontal ligament is not merely a passive layer transmitting load from root to bone. Compression and tension alter signaling within periodontal ligament cells and adjacent bone, initiating coupled resorptive and formative responses that permit the tooth to change position [12]. Consequently, an external force should not be interpreted as a direct biological dose. The same nominal appliance load may produce different tissue-level mechanical environments when root geometry, periodontal

ligament geometry, bone support, or the direction of the applied force differs.

This distinction also constrains the interpretation of computational orthodontics. Finite element analysis can estimate stress, strain, displacement, and force-system behavior that cannot be measured easily in living patients, but its results depend heavily on assumptions regarding material properties, boundary conditions, periodontal ligament representation, and the biological endpoint selected for interpretation. A critical analysis of finite element studies related to orthodontically induced root resorption showed that predicted periodontal ligament stresses vary materially according to whether the ligament is represented with linear or nonlinear constitutive behavior and according to the stress criterion chosen [13]. A simulated stress magnitude is therefore not equivalent to a clinically validated injury threshold. Finite element analysis is best understood as a mechanistic tool for comparing configurations and testing hypotheses rather than a direct measurement of biological tolerance.

The center of resistance illustrates why geometry is so important. In simplified orthodontic teaching, it is often treated as a convenient fixed point through which a force may pass to approximate translation. Patient-derived finite element analysis demonstrates, however, that its location varies with root anatomy, surrounding structures, and the direction of force application [14]. The center of resistance is therefore better regarded as a configuration-dependent property of a tooth-support system than as a permanent anatomical coordinate of the tooth itself. This distinction becomes especially important when support height is reduced, because the geometry defining that tooth-support system has changed.

Orthodontic mechanics are also temporally dynamic. Numerical simulations of longer-term tooth movement demonstrate that contact relationships, movement progression, friction, and changing dental geometry modify the force system as treatment proceeds [15]. An initially favorable line of action may therefore not preserve the same mechanical relationship throughout space closure or other substantial movement. The implication is not that conventional concepts such as force, moment, and center of resistance are obsolete, but that they describe a mechanical state that can evolve.

Tooth morphology and appliance geometry add further variability. Finite element analysis of incisor torque has shown that root form, crown morphology, bracket placement, and prescription can substantially affect the displacement and periodontal ligament response produced by nominally similar torque mechanics [16]. This matters because the clinical language of a “torque prescription” or “translation force” may conceal several different mechanical steps: the force or couple produced by the appliance, its actual line of action relative to the current center of resistance, the resultant stress distribution, and the biological response that follows.

Biological variability further limits a purely mechanical interpretation. Periodontal ligament stem cells subjected to compressive loading show broad transcriptional changes, demonstrating that force exposure initiates complex mechanosensitive cellular responses rather than a single linear pathway [17]. Human-derived periodontal ligament cells also display age-related differences in morphology, molecular activity, and responses after orthodontic force exposure [18]. These observations do not establish age-specific force prescriptions, but they reinforce the principle that identical mechanical inputs cannot be assumed to generate identical biological outcomes across patients.

Taken together, these findings expose several conventional assumptions that become particularly vulnerable in the reduced periodontium. A force magnitude cannot be interpreted independently of the geometry on which it acts. A center of resistance should not be regarded as immutable. A moment-to-force relationship describes only one layer of the total biological system. An initial finite element displacement does not establish long-term clinical movement. Appliance activation is not synonymous with periodontal ligament loading. Most importantly, biomechanical inference must remain separated from clinical validation.

These distinctions form the baseline against which periodontal attachment loss should be interpreted. **Table 1** summarizes the assumptions that are useful in conventional orthodontic mechanics but become incomplete when applied without qualification to teeth with reduced periodontal support.

Table 1. Conventional orthodontic mechanical assumptions requiring reinterpretation when periodontal support is reduced

Conventional assumption	Why the assumption is useful in an intact-support model	What changes when support is reduced	Appropriate interpretation in this article	Principal limit

A prescribed external force has a stable mechanical meaning	Provides a practical description of appliance loading	The same force acts on a different supporting geometry and ligament area	Treat force magnitude as one component of a support-dependent force system	External force does not directly specify tissue-level loading
The center of resistance can be approximated as a fixed tooth-related point	Simplifies prediction of translation and rotation	Loss of support changes the tooth-support relationship and can shift resistance geometry	Treat the center of resistance as configuration-dependent	Exact location remains anatomy- and model-dependent
A given moment-to-force relationship predicts a consistent movement tendency	Supports classification of tipping, translation and root movement	Altered resistance geometry changes the relationship between applied load and rotational tendency	Interpret moment-to-force behavior relative to the current support state	Appliance-level ratios do not fully describe biological response
Appliance activation approximates delivered tooth loading	Facilitates clinical prescription and comparison	Material behavior, force decay, engagement, anchorage and tooth geometry alter transmission	Separate appliance setting from force delivered to the tooth-support system	Bench or simulated loads are not direct PDL measurements
Initial displacement predicts treatment behavior	Useful for comparing mechanical configurations	Remodeling, changing contacts and evolving geometry alter the system over time	Treat initial displacement as a state-specific mechanical prediction	Initial FEA output is not a longitudinal clinical outcome
Mechanical stress can be interpreted independently of biology	Enables analytical simplification	PDL cellular response, vascular state, age and periodontal stability modify tissue behavior	Keep mechanical exposure and biological responsiveness analytically distinct	No universal stress threshold has been clinically validated

How periodontal attachment loss alters mechanical behavior

Periodontal attachment loss changes orthodontic mechanics because it changes the structural system that resists an applied load. Successful periodontal therapy may control inflammation, reduce probing depths, and create a maintainable clinical condition, but it does not recreate the original level and geometry of alveolar support. The tooth therefore remains embedded in a mechanically altered environment. This is the central reason that periodontal stability and biomechanical equivalence should not be treated as the same outcome.

The most direct theoretical consequence concerns the center of resistance and center of rotation. A three-dimensional finite element analysis specifically examining progressive reductions in alveolar bone height demonstrated that the position of the center of resistance changes as support is lost [19]. The exact modeled coordinates are not transferable as universal clinical values, because they depend on the particular anatomy, periodontal ligament assumptions, loading configuration, and boundary conditions used. Nevertheless, the directional principle is important: a tooth with reduced periodontal support is not mechanically equivalent to the same tooth embedded in a normal support height. The geometry governing translation and rotation has changed before the orthodontist changes the appliance.

This observation has consequences for the moment arm of an applied force. If the support-dependent center of resistance shifts while the point and direction of force application remain unchanged, the effective relationship between that force and the resistance geometry also changes. A force that previously produced relatively controlled translation may acquire a greater rotational tendency, whereas a moment designed around conventional support assumptions may no longer have the same relation to the tooth-support system. The clinically meaningful variable is therefore not simply the external force or nominal moment-to-force ratio, but the relationship between those quantities and the altered support geometry.

Periodontal ligament loading is also affected. A mechanobiological finite element study of intrusion in a periodontally compromised posterior tooth found that progressive simulated loss of alveolar support altered hydrostatic stress within the periodontal ligament under intrusive loading [20]. The authors derived different modeled force requirements across support-loss conditions, demonstrating that a load considered acceptable within one geometry cannot automatically be treated as mechanically equivalent after support is reduced. Those numerical values should not be converted into a bedside percentage rule. They belong to a particular model, with particular assumptions about the tooth, ligament, support loss, material

behavior, and stress criterion. Their stronger contribution is conceptual: reducing the support structure can alter tissue loading even when the intended movement remains the same.

This principle can be explained through geometry rather than through a universal equation. As attachment support is lost, the remaining periodontal ligament area available to distribute load is reduced and the spatial relationship between the applied force and the support system changes. The resulting stress distribution can become more concentrated or differently located. At the same time, root form, defect morphology, direction of bone loss, crown-root relationship, neighboring teeth, anchorage, and force application point can modify the response. Two teeth with the same millimeters of radiographic bone loss need not therefore have identical biomechanical behavior.

The distinction between horizontal support reduction and more complex defect morphology is especially important. A simplified finite element model may represent a relatively uniform apical shift in the bone level, whereas clinical periodontal destruction can be angular, asymmetric, interproximal, circumferential, or associated with furcation involvement. These configurations may alter local stress pathways in ways that are not captured by a single "percentage bone loss" variable. The theoretical implication is that attachment geometry is not merely a quantity of missing support; it is also a spatial configuration.

Periodontal inflammation adds a separate biological dimension. The clinical evidence reviewed earlier supports orthodontic movement primarily in patients whose periodontal disease has been treated and is under maintenance. That condition should be understood as a prerequisite for interpreting mechanics, not as proof that the tissue response is identical to that of an intact periodontium. In an active inflammatory environment, altered vascularity, ongoing connective-tissue destruction, microbial challenge, and uncontrolled bone loss would confound the interpretation of mechanical loading. In a stable reduced periodontium, the dominant theoretical problem becomes different: how should an orthodontic force system be interpreted when biological control is acceptable but structural support remains reduced?

This separation prevents a common conceptual error. "Light forces" are often recommended broadly in periodontal-orthodontic discussions, but the phrase can become clinically vague if it is detached from force direction, moment generation, movement objective, root geometry, remaining support, and anchorage. A numerically smaller force is not automatically a mechanically appropriate force. An intrusive load, a translational force, a tipping force, and a torque-producing couple interact with reduced support differently. The next analytical step must therefore move beyond the generic instruction to reduce force and reconstruct the logic of prescription for distinct movement systems.

Before that reconstruction, the support-dependent consequences developed in this section can be organized by the mechanical variable that changes. **Table 2** distinguishes the effects of reduced periodontal support on common orthodontic movement objectives without converting model-derived observations into universal treatment thresholds.

Table 2. Mechanical implications of reduced periodontal support for common orthodontic movement objectives

Movement objective	Principal mechanical requirement	Effect of reduced support on interpretation	Main biomechanical concern	Appropriate clinical-theoretical reading
Controlled tipping	Force acting with a limited counter-moment	Altered resistance geometry can change the rotational response to the same line of action	Excessive crown displacement or altered root loading	Reassess force line and rotational tendency relative to current support
Translation	Force system positioned to minimize net rotation	A shifted center of resistance can change the moment required to approach bodily movement	Apparent translation prescription may produce unintended rotation	Treat translation as support-dependent rather than defined by a fixed textbook ratio
Root movement / torque	Sufficient couple or moment to displace the root relative to the crown	Reduced support alters lever geometry and periodontal ligament stress distribution	Localized root-side stress and loss of intended rotational control	Separate appliance torque setting from actual tooth-support mechanics

Intrusion	Axially directed force with control of tipping and anchorage	Reduced support can increase or redistribute periodontal ligament stress under the same nominal force	Load concentration in a smaller or differently configured support system	Avoid converting modeled force reductions into universal numerical rules
Extrusion	Controlled coronal displacement with attention to periodontal and occlusal context	Support loss may change the coupling between coronal movement and rotational tendency	Unintended tipping, occlusal interference, tissue response	Interpret extrusion through current support geometry and clinical periodontal status
Space closure / retraction	Coordinated force, moment, anchorage and evolving contact relationships	Altered support modifies resistance while treatment itself changes geometry over time	Progressive loss of initially intended force-system behavior	Reassess mechanics as treatment state changes rather than assuming a static prescription
Distalizatio n and other complex multi-tooth movement	Anchorage control and management of coupled rotations/intrusions	Unequal periodontal support can create asymmetric resistance among teeth	Unwanted secondary movements and uneven load distribution	Evaluate support at tooth and segment levels rather than prescribing from appliance activation alone

Reconstructing force-prescription logic

Once periodontal support is reduced, prescription should shift from naming a nominal force to interpreting the complete force system acting on the current tooth-support configuration. This is particularly evident in torque. Finite element analysis of anterior retraction with clear aligners demonstrates that changes intended to increase root control also modify rotational behavior and stress distribution [21]. Alternative fixed-appliance torque mechanics similarly produce materially different root and crown responses despite pursuing the same nominal movement objective [22]. Torque should therefore be regarded as an interaction among couple generation, force application, root geometry, support geometry, and the resulting center-of-rotation behavior rather than as an appliance property alone.

The same distinction applies to force magnitude. Mechanical testing of orthodontic aligners shows that material, manufacturing method, and surface configuration can alter the force delivered for the same imposed displacement [23]. Auxiliary configuration further changes how a nominal activation is converted into tooth displacement and periodontal ligament loading [24]. Finite element comparisons of archwire and power-arm arrangements likewise demonstrate that the vertical position of force application can shift movement from uncontrolled rotation toward bodily or root-dominant behavior [25]. These findings do not define a preferred appliance for the reduced periodontium. They show why an appliance setting cannot substitute for an interpretation of the force system that actually reaches the tooth-support complex.

Prescription must also account for treatment stage. Sequential modeling of extraction-space closure demonstrates that the biomechanical state evolves as teeth change position [26]. A configuration that generates a desirable force system at one stage may not maintain it later. Anchorage modifies this further. Miniscrew location and the mode by which anchorage is connected to the dentition can change distalization, tipping, intrusion, and periodontal ligament stress patterns [27]. In a dentition with unequal periodontal support, this principle becomes especially important because the teeth participating in anchorage may not have equivalent resistance.

Intrusion illustrates the danger of converting a movement label into a universal force instruction. Initial incisor inclination changes the moment and displacement tendencies produced during simulated intrusion [28]. Canine movement likewise changes with activation magnitude and power-arm geometry, with corresponding differences in periodontal ligament stress [29]. Such studies establish configuration sensitivity but not clinically validated numerical tolerance limits.

Clinical evidence imposes an additional boundary. A systematic review of maxillary molar intrusion found that several approaches can produce intrusion, yet the certainty of evidence concerning comparative effectiveness, adverse effects, and longer-term stability remains very low [30]. Moreover, three-dimensional clinical evaluation of aligner treatment has shown that digitally prescribed distal movement, intrusion, tipping, and torque are not reproduced perfectly in the achieved dentition [31]. Prescription, delivered

mechanics, and observed movement are therefore distinct layers.

A defensible force prescription in reduced support should consequently answer four questions: what movement is intended; where the current center of resistance is likely to lie relative to the force system; how attachment geometry may modify periodontal ligament loading; and how strongly the expected response is supported by clinical rather than simulated evidence. The answer need not produce a numerical reduction factor. Indeed, the existing evidence does not justify one. Its function is to prevent a force that appears modest at the appliance level from being interpreted as mechanically equivalent across different support states.

The interaction among attachment geometry, resistance location, force application and movement tendency is consolidated in **Figure 1**. The figure deliberately separates externally delivered mechanics from the altered support system and from the resulting interpretation of tooth movement.

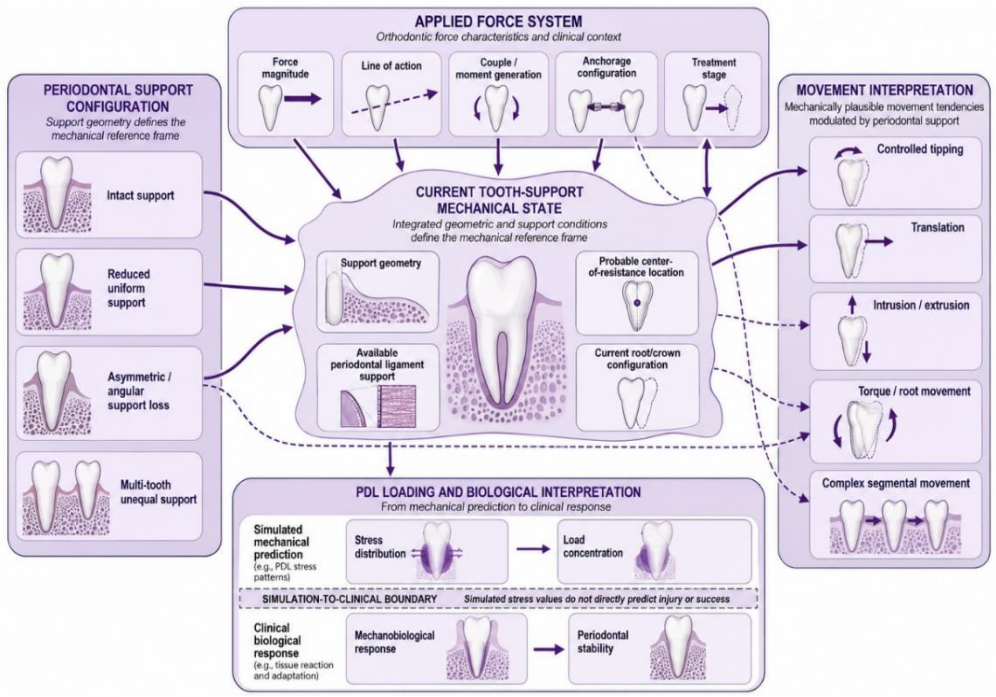

Figure 1. Attachment loss reorganizes the mechanical reference frame of orthodontic force systems

A support-dependent biomechanical interpretation framework

The preceding evidence suggests that force prescription should be reframed as interpretation under changing support conditions. The proposed framework does not generate an "optimal force" and should not be read as a treatment algorithm. Its function is to discipline reasoning by keeping four variables separate: periodontal support geometry, the delivered force system, biological periodontal status, and the evidentiary status of the predicted response.

The first variable is support geometry. Evidence that the center of resistance changes as alveolar support is reduced means that attachment loss modifies the mechanical coordinate system within which force and moment are interpreted [19]. The second variable is the delivered force system. Model-based studies of intrusion indicate that identical nominal loading can produce different periodontal ligament stress when support changes [20]. Appliance activation alone is therefore an incomplete descriptor.

The third variable is biological status. A stable reduced periodontium may be an appropriate environment for carefully controlled orthodontic movement, whereas active disease changes the biological context fundamentally. Periodontal stabilization is consequently a clinical prerequisite in relevant patients, but it should not be misread as restoration of intact-support mechanics [4].

The fourth variable is evidence status. Model selection materially influences predicted periodontal ligament stress [13]. Clinical evidence for particular movements can also remain uncertain despite biomechanical plausibility [30]. In addition, digitally intended movement can differ from achieved movement [31]. A theoretical prediction, an initial finite element displacement, an observed clinical movement and a periodontal outcome therefore occupy different evidentiary levels.

The framework interprets an orthodontic plan by asking whether these four dimensions are mutually compatible. A movement may be mechanically plausible yet biologically inappropriate because periodontal control is insufficient. It may be biologically permissible yet mechanically uncertain because support is asymmetric or the center of resistance cannot be approximated reliably. It may be mechanically elegant in a simulation yet clinically weak because the proposed response has not been validated in patients. Conversely, a clinically successful treatment does not establish that its precise force system is universally transferable.

This support-dependent interpretation is summarized in **Figure 2**.

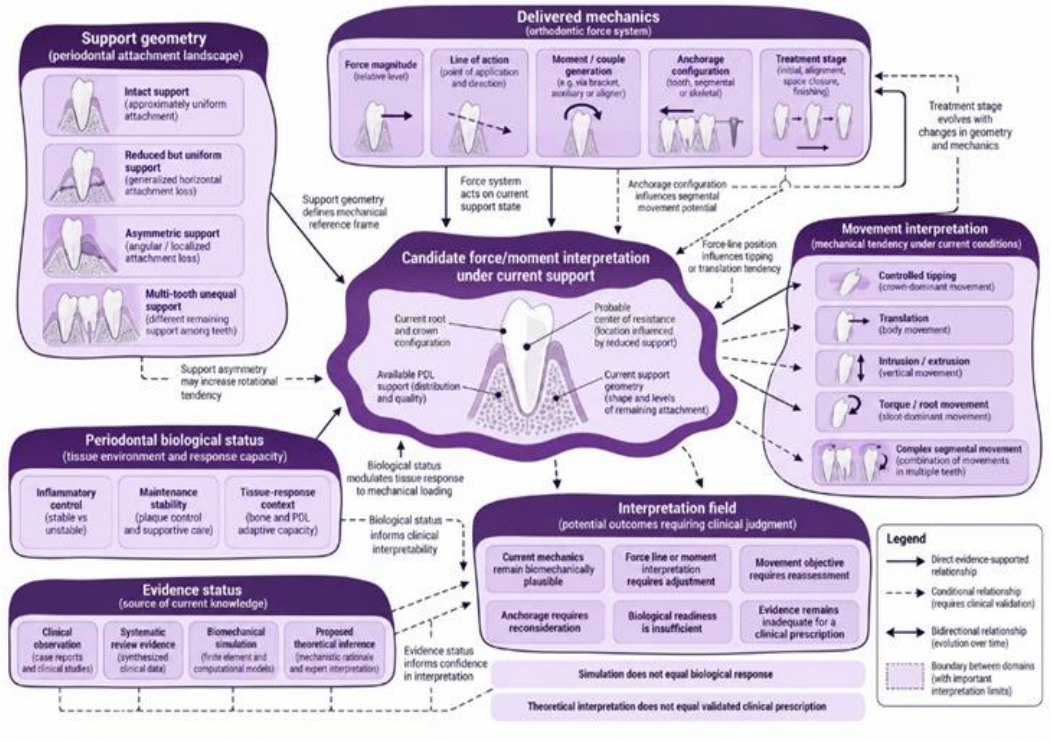

Figure 2. Conditional interpretation of force and moment under reduced periodontal support

Clinical interpretability and theoretical limitations

The practical implication of a support-dependent approach is not that every tooth with periodontal attachment loss requires a predetermined fraction of conventional force. Such a rule would exceed the evidence. The clinically defensible implication is narrower: support loss should prompt reconsideration of how the chosen force system relates to the altered tooth-support geometry.

This distinction matters because periodontal stability and mechanical integrity answer different questions. Evidence supports orthodontic treatment in selected patients after periodontal control, yet neither successful maintenance nor absence of active inflammation restores lost attachment. The clinician therefore has to evaluate biological readiness and mechanical configuration in parallel.

Finite element models are especially useful for demonstrating why this distinction matters, but they remain representations. Predictions depend on ligament properties, bone geometry, load definition, contact assumptions and the selected mechanical endpoint [13]. Model-derived stress concentrations or force reductions should therefore be used to identify mechanisms and comparative tendencies, not to manufacture universal clinical thresholds.

The same caution applies to clinical translation. Very-low-certainty evidence for some movement modalities means that apparently precise biomechanical recommendations can exceed what patient studies actually support [30]. Differences between digitally planned and achieved three-dimensional movement further show that even a well-specified force system passes through appliance behavior, biological remodeling, compliance, anatomical variation and treatment-stage changes before an outcome is observed [31].

Several dimensions of attachment loss also remain incompletely represented. Clinical defects are often asymmetric and spatially complex, whereas many mechanical studies simplify support reduction. Multi-rooted teeth, furcation involvement, varying root

morphologies, unequal support within a segment and combined restorative or occlusal constraints may all modify resistance in ways that cannot be captured by a single measure of bone height. The present framework should consequently be treated as an interpretive structure for organizing these variables, not as a substitute for individualized periodontal and orthodontic assessment.

Future research should connect mechanics and clinical outcomes more directly. Patient-specific modeling could be prospectively compared with delivered tooth movement, periodontal stability and adverse events. Studies should report the actual support configuration, force-delivery system and treatment stage rather than describing an intervention only by appliance type. Validation should also test whether predicted changes in resistance geometry improve clinical planning beyond conventional assessment. Until such evidence exists, the most defensible contribution of support-dependent biomechanics is improved interpretation rather than numerical prescription.

Conclusion

Orthodontic force prescription in the reduced periodontium should not be understood as the simple application of a smaller version of an otherwise unchanged force system. Periodontal attachment loss alters the geometry through which orthodontic loads are resisted and can change center-of-resistance behavior, rotational tendency and periodontal ligament loading. At the same time, successful periodontal stabilization can permit orthodontic treatment in appropriately selected patients, meaning that reduced support is neither mechanically irrelevant nor an automatic contraindication.

The resulting clinical problem is therefore interpretive. Force magnitude, line of action, moment generation, anchorage, movement objective, treatment stage, periodontal support and biological stability must be considered together. Existing biomechanical models justify this support-dependent reasoning but do not establish universal force-reduction thresholds, and current clinical evidence does not validate model-derived stress values as direct patient prescriptions. A defensible approach is consequently to treat attachment geometry as a modifier of orthodontic force-system interpretation while maintaining a clear boundary between simulation, theoretical synthesis and clinically demonstrated response.

Acknowledgments: None

Conflict of Interest: None

Financial Support: None

Ethics Statement: None

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