

Review

Vertical Control Strategies in Open Bite Correction: A Review of Biomechanical Approaches

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Abstract

Open bite malocclusion remains one of the most complex conditions to diagnose and manage due to its multifactorial etiology and high relapse potential. Vertical control is critical in both surgical and non-surgical correction strategies, with biomechanical precision playing a decisive role in the quality and stability of the outcome. Advances in skeletal anchorage systems, particularly the use of temporary anchorage devices and miniplates, have transformed the approach to vertical correction. These methods enable controlled intrusion of posterior or anterior teeth without relying on traditional dental anchorage, thus minimizing side effects and maximizing skeletal changes, especially in adult patients with limited growth potential. Posterior intrusion facilitates mandibular autorotation, which can significantly improve the vertical facial dimension, while anterior intrusion is used to correct incisor overeruption in dental open bites. However, each approach demands an understanding of force vectors, centers of resistance, and tissue response to ensure predictable outcomes. Skeletal anchorage has shown higher success rates in maintaining vertical changes post-treatment, though relapses remain a concern. Factors such as tongue posture, growth patterns, and compliance with retention protocols influence the longevity of treatment results. Stability depends not only on the mechanics used during active treatment but also on how well functional habits are addressed and whether long-term retention is tailored to the patient's risk of relapse. The integration of myofunctional therapy and occlusal coverage retainers is being increasingly explored to support vertical control after treatment. Clinical decisions regarding anchorage choice, force application, and retention design must be guided by both skeletal morphology and soft tissue function. As techniques evolve, individualized biomechanics supported by interdisciplinary management are essential for effective open bite correction and sustainable results in vertical dimension control.

Keywords: *open bite, vertical control, skeletal anchorage, molar intrusion, orthodontic relapse*

Introduction

Open bite malocclusion presents one of the most complex and multifactorial challenges in orthodontics. Characterized by a lack of vertical overlap between the anterior or posterior teeth, open bite can manifest as either skeletal or dental in origin, with the former often involving vertical maxillary excess or increased mandibular plane angle. The etiology is frequently attributed to a combination of genetic predisposition, aberrant growth patterns, functional habits such as tongue thrusting or digit sucking, and airway obstruction-related postural adaptations (1). The successful correction of open bite hinges not only on achieving adequate tooth alignment and occlusion, but also on exerting precise vertical control to modify or redirect unfavorable dentofacial growth.

Biomechanical approaches to open bite correction have evolved significantly with advances in anchorage control, particularly with the integration of temporary anchorage devices (TADs) and skeletal anchorage systems. These developments have enabled clinicians to perform targeted intrusion of molars or incisors with minimal reciprocal effects, thereby reducing the need for extensive extractions or orthognathic surgery in selected cases (2). Conventional strategies, such as high-pull headgear or posterior bite blocks, continue to play a role, particularly in growing patients, but are often limited by dependence on patient compliance and skeletal maturity. Fixed appliances that employ differential moments and force systems are also widely used, especially in conjunction with vertical elastics, yet the balance between desired intrusion and unintended extrusion remains a biomechanical concern.

The vertical dimension is a critical determinant of facial aesthetics and function. Controlling this dimension during open bite treatment requires an in-depth understanding of force vectors, centers of resistance, and the impact of vertical mechanics on the surrounding dentoalveolar and skeletal structures. For instance, molar intrusion has been shown to lead to counterclockwise autorotation of the mandible, which can be advantageous in

reducing anterior open bite and improving chin projection in hyperdivergent patients (3). Conversely, excessive intrusion or unplanned force application may compromise root integrity, periodontal health, or temporomandibular joint stability. These risks underscore the importance of biomechanical precision and individualized treatment planning.

Long-term stability of open bite correction remains a subject of ongoing investigation. Despite successful short-term closure, relapse is frequently reported due to persistent etiological factors or insufficient retention strategies. The vertical vector of force applied during treatment, the age of the patient, and the type of anchorage employed are all significant predictors of relapse. Therefore, clinicians must integrate biomechanical strategies with retention protocols that address both the dentoalveolar and functional components contributing to the open bite tendency (4). This review will discuss vertical control strategies in open bite correction and the different biomechanical approaches.

Review

Vertical control in open bite correction demands careful biomechanical planning to achieve stable outcomes while minimizing unwanted side effects. The advent of skeletal anchorage systems has significantly enhanced the ability to intrude posterior teeth, especially molars, which facilitate mandibular autorotation and reduction of anterior open bite without the need for extractions. This technique has proven effective particularly in adult patients, where growth modification is no longer viable (5). Compared to conventional methods, such as vertical elastics or headgear, skeletal anchorage offers superior control over force direction and magnitude, leading to more predictable vertical outcomes.

Despite these advantages, the long-term stability of open bite correction continues to present challenges. Studies have shown that molar intrusion achieved through temporary anchorage devices can relapse, particularly when retention protocols are insufficient or when etiologic factors like tongue

posture are not addressed. This emphasizes the importance of incorporating functional re-education and long-term retention planning into the treatment strategy (6, 7). Additionally, the distribution of forces must be carefully monitored to avoid root resorption or alveolar bone loss. A multidisciplinary approach that considers both biomechanical and functional aspects is essential for sustainable correction and improved patient satisfaction.

Biomechanical Principles of Anterior and Posterior Intrusion

Posterior intrusion, especially of the maxillary molars, is frequently indicated in skeletal open bite cases characterized by excessive posterior vertical growth and increased mandibular plane angles. When molars are intruded successfully, the mandible tends to autorotate counterclockwise, reducing anterior open-bite and improving chin projection. Miniplates and miniscrews placed in the infrazygomatic crest or palatal regions are preferred due to their stability and ability to deliver vertical intrusive forces directly along the long axis of molars. The intrusion achieved through skeletal anchorage is more predictable than with conventional appliances, as it minimizes reciprocal effects commonly observed with vertical elastics or bite blocks (8).

Anterior intrusion, on the other hand, is generally indicated in dental open bites or in situations involving excessive incisor display. The biomechanical approach typically involves the application of intrusion forces via utility arches, segmental mechanics, or skeletal anchorage systems. Applying forces too far from the center of resistance of the anterior teeth, such as from the gingival or labial direction, risks uncontrolled tipping or root resorption. To achieve bodily intrusion, clinicians often combine palatal and labial forces or employ intrusion arches that generate a moment-to-force ratio conducive to controlled vertical movement. Studies involving finite element analysis have illustrated how different force vectors and appliance designs influence stress distribution along the periodontal ligament during incisor intrusion, providing a more refined framework for clinical application (9). While molar intrusion often

results in favorable mandibular repositioning, it is not without complications. Excessive intrusion force can lead to root resorption, particularly in multi-rooted molars, where stress concentration near the furcation is common. To mitigate these risks, gradual loading protocols and regular radiographic monitoring are necessary. Furthermore, maintaining the achieved vertical correction over time depends on periodontal support and neuromuscular adaptation. Habits such as tongue thrust or mouth breathing can compromise results, which makes functional training an important adjunct to mechanical correction.

In some treatment protocols, simultaneous anterior and posterior intrusion are employed, particularly when vertical excess spans across both dental and skeletal components. For such complex cases, force systems must be carefully balanced to prevent occlusal plane rotation or unwanted shifts in midline. Skeletal anchorage allows for this type of dual-vector force application without compromising patient comfort or requiring elaborate appliance systems. The versatility of skeletal anchorage lies in its ability to isolate force vectors and apply them precisely where needed, making it an indispensable tool in modern vertical control strategies (10). Clinical decision-making must also take into account the periodontal biotype, root morphology, and alveolar bone density, as these factors influence tissue response to intrusion forces. A thin biotype may be more prone to gingival recession, whereas a thicker phenotype may withstand intrusion with fewer complications (11).

Role of Skeletal and Dental Anchorage in Vertical Control

Anchorage control is a cornerstone in managing open bite malocclusion, particularly when vertical correction is the primary treatment goal. In this context, the choice between skeletal and dental anchorage systems directly influences the biomechanical efficiency, force direction, and stability of intrusion movements. Skeletal anchorage, primarily involving TADs and miniplates, has emerged as a reliable method for vertical control due to its ability to deliver absolute anchorage without relying on tooth support. By

contrast, dental anchorage systems, including transpalatal arches, Nance appliances, or inter-arch elastics, often involve reciprocal forces that may lead to unwanted tooth movements.

Skeletal anchorage devices are placed in extra-radicular areas, such as the infrazygomatic crest, anterior palate, or mandibular buccal shelf. These locations allow clinicians to apply vertical forces directly to the posterior or anterior teeth without affecting adjacent units. This makes them highly suitable for molar intrusion, a strategy often used to facilitate mandibular autorotation and improve facial balance. A prospective study evaluating intrusion mechanics using miniscrews in the infrazygomatic region demonstrated effective vertical reduction in posterior dentoalveolar height with minimal discomfort or complications, affirming the clinical value of skeletal anchorage in vertical dimension management (11).

Dental anchorage, although more traditional, still plays a role in certain open bite cases, especially when skeletal growth is ongoing or patient cooperation is high. Appliances like high-pull headgear are designed to restrict maxillary growth and posterior eruption, which can assist in controlling vertical development during adolescence. However, these methods are inherently dependent on patient compliance and tend to lose effectiveness once growth ceases. Furthermore, force vectors are less controlled, leading to side effects such as incisor flaring or molar tipping. In contrast, fixed dental anchorage systems can offer more consistent results, but they still involve shared anchorage across teeth, which can cause undesirable shifts in occlusion if not monitored carefully.

The stability of skeletal anchorage has also expanded treatment options in non-growing patients. Open bite cases in adults, once limited to orthognathic surgery or extractions, can now be managed more conservatively using TADs. When used in combination with segmented arch mechanics, TADs can produce controlled intrusion of molars or incisors without compromising the occlusal plane. For instance, maxillary molar intrusion performed with miniscrews in adult

patients has resulted in significant improvements in overbite and lower anterior facial height, as observed in longitudinal clinical trials with follow-up periods extending beyond two years (12).

Beyond mechanical effectiveness, anchorage selection must account for biological limitations. Root proximity, soft tissue irritation, and bone density variations can influence TAD stability. A large-scale retrospective study examining miniscrew failure rates found that placement torque, site selection, and mucosal thickness were significant predictors of clinical success (13). Dental anchorage systems, while less invasive, are not exempt from complications either. Anchorage loss, root resorption, and excessive force distribution are common concerns when forces are poorly managed. In growing patients, molar extrusion resulting from inter-arch elastics may worsen the vertical discrepancy instead of correcting it.

Clinical protocols that integrate skeletal anchorage with conventional mechanics have been shown to enhance treatment efficiency and allow greater control over the vertical plane. These hybrid systems use skeletal anchorage for primary force delivery while employing dental anchorage for auxiliary stabilization or coordination. Such approaches have proven particularly effective in deep anterior bite corrections, where force direction and anchorage control require fine adjustments to achieve predictable vertical outcomes (14).

Post-Treatment Stability and Risk of Open Bite Relapse

Long-term success in open bite correction depends not only on achieving vertical closure but also on maintaining it beyond active treatment. Post-treatment relapses remain a persistent challenge, especially in cases where the underlying etiologic factors were not fully addressed. Open bite tends to recur more frequently than other malocclusions, particularly when treatment focuses solely on dentoalveolar movement without modifying habits, functional patterns, or skeletal imbalances. The vertical dimension is inherently more unstable, and

small shifts in molar position, tongue posture, or muscular tone can gradually reopen an anterior gap.

Studies tracking stability after intrusion of molars using skeletal anchorage show promising short-term outcomes, but even in these cases, relapses occur. Some patients display re-eruption of previously intruded molars during retention, which alters mandibular posture and compromises the occlusion. Cephalometric analyses comparing immediate post-treatment and long-term follow-ups show that vertical relapses can occur even with fixed retainers in place, suggesting that passive stabilization alone is insufficient. For example, a study evaluating adult patients treated with skeletal anchorage reported significant relapse in posterior intrusion at two-year follow-up, with partial re-opening of the anterior bite, particularly in those who discontinued retention prematurely (15).

Functional habits contribute substantially to relapsing. Tongue posture, in particular, has a direct effect on vertical tooth position. Patients who exhibit forward or low tongue posture during rest and swallowing exert continuous light forces on the anterior teeth, counteracting the effects of previous intrusion. Even in patients with initially good compliance and favorable skeletal morphology, failure to address tongue function can compromise outcomes. Incorporating myofunctional therapy into the retention phase has been proposed as a way to promote neuromuscular adaptation. A clinical report analyzing patients treated with both intrusion mechanics and functional therapy found better vertical stability than in those who received mechanical correction alone (16).

Skeletal maturity at the time of treatment also influences long-term outcomes. Younger patients undergoing treatment before the completion of vertical growth may experience reopening as the maxilla or mandible continues to develop. Growth-related changes in mandibular plane angle or maxillary rotation can alter the occlusal relationship, especially in patients with hyperdivergent skeletal patterns. These skeletal tendencies persist well in adolescence and early adulthood, which makes timing a critical factor. A

retrospective review of adolescent open bite cases found a higher relapse rate among patients treated before the pubertal growth spurt compared to those treated at or after its completion (17).

Retention design plays a key role in post-treatment control. Removable retainers, while commonly prescribed, are often limited in their ability to resist vertical relapses due to poor patient compliance and minimal coverage of posterior teeth. Modified Hawley retainers or vacuum-formed devices with occlusal coverage have been developed to preserve posterior intrusion and anterior contact. Some clinicians advocate for long-term, full-coverage retainers in high-risk cases, particularly when skeletal correction was not part of the treatment plan. Comparative studies between fixed and removable retainers in open bite cases suggest higher stability with designs that offer vertical support beyond the incisor region (18).

Conclusion

Effective vertical control in open bite correction relies on precise biomechanics, appropriate anchorage selection, and long-term retention planning. Skeletal anchorage has expanded treatment possibilities, particularly in adults, offering greater predictability in vertical dimension management. Stability remains a central concern, often influenced by unresolved functional habits and growth patterns. A multidisciplinary approach enhances both treatment outcomes and post-treatment maintenance.

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Data availability

All data is available within the manuscript.

Author contribution

All authors contributed to conceptualizing, data drafting, collection and final writing of the manuscript.

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