# ALIGNERS IN ORTHODONTICS: A REVIEW

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## ABSTRACT

Orthodontic treatment has evolved significantly over the years, with aligner therapy emerging as a popular alternative to traditional braces. Aligners offer patients a discreet and convenient option for correcting malocclusions and achieving desirable aesthetic outcomes. This review article comprehensively explores the development, mechanism, advantages, limitations, and clinical effectiveness of aligners in orthodontics. By analysing current research and clinical experiences, this review aims to provide orthodontists, dentists, and patients with a thorough understanding of aligner therapy and its place in modern orthodontic practice.

**Keywords:** Orthodontics, aligner therapy, clear aligners, malocclusion, aesthetic orthodontics, orthodontic appliances.

## INTRODUCTION

The landscape of orthodontic care has been undergoing a notable transformation, marked by a surge in adults seeking orthodontic treatment for improved aesthetics and comfort. This shift has sparked a corresponding demand for orthodontic appliances that offer both enhanced aesthetic appeal and greater comfort than traditional fixed appliances. As the preferences of patients evolve, the concept of Clear Aligner Therapy has risen to prominence, offering a range of appliances with varying mechanisms of action, construction methods, and applicability to different malocclusion treatments.1 The essence of Clear Aligner Therapy revolves around the utilization of clear thermoformed plastic aligners that cover a significant portion, if not all, of the teeth. While this commonality serves as a foundational point, the diversity among Clear Aligner Therapy systems becomes evident when considering the substantial differences that impact their efficacy in treating diverse orthodontic issues.2 Some Clear Aligner Therapy systems were initially designed to address minor irregularities in tooth position, while others boldly claim effectiveness in tackling complex malocclusions. However, the scarcity of robust clinical evidence supporting such claims has left certain aspects of Clear Aligner Therapy under scrutiny.3 Furthermore, the accessibility of certain Clear Aligner Therapy systems to the public, without requiring professional dental oversight, raises concerns about the quality and safety of these interventions. An important divergence among Clear Aligner Therapy systems involves the incorporation of bonded resin attachments on teeth. These attachments extend the scope of aligner treatment by enabling movements that were traditionally considered challenging or unattainable through Clear Aligner Therapy alone. Technological advancements play a significant role in the Clear Aligner Therapy landscape, affecting aligner materials, appliance design, and manufacturing processes. However, this rapid evolution has led to challenges in evaluating Clear Aligner Therapy efficacy scientifically.4 The dynamism of Clear Aligner Therapy systems often outpaces the time required to gather, analyze, and publish data from past treatments. This discrepancy renders some studies outdated by the time they are published. A notable observation in the orthodontic community came in 2012 when Robert Keim, editor of the Journal of Clinical Orthodontics, highlighted two significant advances in orthodontics over the preceding 15 years: temporary anchorage devices and Invisalign. The latter, represented by clear aligners like Invisalign, was identified as a game-changing alternative to traditional braces. It was asserted that today, practically any malocclusion can be successfully treated using this or similar technologies.5 This testament to the efficacy of clear aligners reflects the evolving landscape of orthodontics driven by patient demand for esthetic, comfortable, and technologically advanced treatment options. Nevertheless, the cost of production, reliance on patient compliance, and limitations in treating specific malocclusions continue to shape the scope of clear aligner adoption within the orthodontic field.

## DEVELOPMENT OF ALIGNER THERAPY

Though the concept of aligner therapy has historical underpinnings dating back to the mid-20th century, its transformative growth occurred in the late 1990s, Clear Aligner Therapy by the fusion of computer-aided design and manufacturing (CAD/CAM) techniques. This synergy facilitated the birth of commercial aligner systems that redefined orthodontic approaches. While the formal introduction of clear aligners to orthodontic practice dates back to the FDA approval of Invisalign for orthodontic use in 1998, traces of this technology can be found in earlier iterations, such as Dr. Harold Kesling's Tooth Positioner in 1946.6 Aligner therapy stands as a natural extension of concepts like tooth positioners, spring aligners, and other historical orthodontic approaches. Over time, these concepts were refined by pioneers like Nahoum, Ponitz, McNamara, Sheridan, and Truax, culminating in contemporary clear aligner products bolstered by advancements in transparent thermoplastic materials and computer technology. 7The pivotal year of 1999 witnessed the introduction of Invisalign, heralding the inception of the first successful clear aligner system. This watershed moment initiated a shift from traditional fixed appliances towards a dynamic methodology characterized by a sequence of transparent, removable aligners. These aligners, designed to snugly embrace the dental arch, silently applied controlled forces to teeth, steering precise movements. Underpinning aligner therapy is the innovative application of Clear Aligner Therapy of

advanced computer technology for treatment planning and aligner Clear Aligner Therapy. Three-dimensional digital models of patients' dentition serve as canvases for meticulous analysis and predictions of tooth shifts. This digital precision, complemented by the malleability of CAD/CAM manufacturing, empowers the creation of tailor-made aligners aligned with each patient's distinct needs.8 This evolutionary journey from aligner therapy's inception to contemporary prominence bears the imprint of sustained innovation. Gradually, the scope of aligner therapy transcended minor tooth irregularities to encompass a spectrum of orthodontic cases. Aligner systems evolved, integrating attachments and adjunct components to address complex malocclusions that had once eluded this approach. However, the evolution of aligner therapy encountered hurdles. The rapid pace of technological advances and the constant evolution of aligner materials, designs, and manufacturing techniques have posed challenges for systematic evaluation.

## MECHANISM OF ACTION:

Understanding the mechanics of tooth movement using clear aligners is crucial for effective treatment planning and improved outcomes. Two primary approaches, the displacement driven system and the force driven system, govern tooth movement with aligners. The former is suited for simpler movements like tipping, while the latter, supported by biomechanical principles, achieves more complex repositioning.9 Aligners, designed through advanced software, exert controlled forces on teeth, and their shape can be altered using pressure points or power ridges. Attachments further enhance the system, allowing for intricate movements like extrusion, rotation, and root control. The incorporation of temporary anchorage devices (TADs) in conjunction with aligners has expanded treatment possibilities.9 This understanding of aligner mechanics ensures precise treatment sequences, enabling better patient selection and superior results. The aligners are constructed from transparent thermoplastic materials, lending them an inconspicuous appearance that aligns with patient preferences for aesthetics. Each aligner fits snugly over the dental arch, ensuring intimate contact with the teeth. Through consistent wear, the aligner exerts controlled forces on the teeth, prompting gradual repositioning. This process occurs as the aligner's material reacts to the forces applied, transmitting pressure to the teeth and initiating the biomechanical shifts required for tooth movement. The sequential nature of aligner therapy facilitates a progressive cascade of tooth movements.10 As the patient advances through the aligner series, the dentition gradually aligns with the treatment plan. The planning and execution precision, enabled by CAD/CAM technology, minimizes the risk of undesirable movements and ensures that the intended alignment is achieved.

## ADVANTAGES OF ALIGNER THERAPY

Clear aligners, fabricated from transparent thermoplastic materials, offer a nearly invisible treatment option. Patients often favor aligners over conventional braces for their discreet appearance, enabling them to undergo orthodontic treatment without drawing undue attention to their teeth. Aligners lack the brackets and wires associated with fixed appliances, minimizing oral irritation and discomfort. The smooth edges of aligners ensure a more comfortable experience, reducing the likelihood of soft tissue abrasions and ulcers. The removability of aligners empowers patients to maintain optimal oral hygiene practices. Unlike fixed appliances, where cleaning around brackets and wires can be challenging, aligners can be easily removed for thorough brushing, flossing, and cleaning. This diminishes the risk of plaque accumulation, cavities, and gingival inflammation. Aligners' removability grants patients the freedom to enjoy a varied diet without restrictions.11 Unlike braces, where certain foods must be avoided to prevent damage, aligner wearers can simply remove their aligners before

eating, eliminating concerns about food getting trapped. Aligner therapy typically involves fewer in-person appointments compared to traditional braces. While fixed appliances necessitate periodic adjustments and maintenance, aligners follow a predetermined treatment plan that requires fewer monitoring visits. This convenience appeals to busy individuals seeking orthodontic treatment. Aligners contribute to a positive orthodontic journey. Patients often experience less discomfort and experience fewer emergency visits related to broken wires or brackets. The absence of discomfort and the discreet nature of aligners contribute to a more positive overall treatment experience. The integration of advanced technology, such as computerized treatment planning and CAD/CAM manufacturing, enhances treatment predictability. Clinicians can accurately forecast the course of treatment, providing patients with a clear understanding of the expected outcomes and timeline. Aligners not only deliver aesthetic improvements but can also address functional issues associated with malocclusions. Patients may notice improvements in speech, chewing efficiency, and overall oral function as teeth are guided into more optimal positions.12,13

## LIMITATIONS OF ALIGNER THERAPY

Aligner therapy is ideally suited for mild to moderate malocclusions. Complex cases involving significant skeletal discrepancies or severe tooth movements may not be effectively addressed solely through aligners. The success of aligner therapy hinges on consistent patient compliance. Aligners must be worn for the prescribed duration each day to achieve the intended tooth movements. Patients who fail to wear aligners as instructed may experience treatment delays or compromised outcomes. Aligners primarily achieve controlled crown movements, such as tipping and rotation. However, achieving precise root movements, particularly vertical control (extrusion or intrusion), can be challenging with aligners alone. While technological advances enhance treatment planning accuracy, aligner therapy outcomes can still be influenced by individual variations in tooth movement response. Unforeseen factors, like atypical root resorption, might impact treatment predictability. Aligner therapy might require a longer treatment timeline compared to certain other orthodontic methods.10 Complex cases or patients who require extensive tooth movement may necessitate extended treatment durations. Aligners might not be the optimal choice for patients with significant bite discrepancies that require extensive orthodontic interventions to address skeletal discrepancies. Aligner therapy might not provide the same degree of control over the eruption patterns of teeth as traditional fixed appliances do. Aligner therapy can be more expensive than traditional braces, and some insurance plans may not fully cover aligner treatment.Class II malocclusions often involve intricate skeletal and dental relationships. Achieving significant skeletal corrections, such as mandibular advancement, might be beyond the scope of aligner therapy's capabilities.Clear aligners primarily control tooth movement and may not provide the necessary skeletal changes required for Class II correction. While aligners can assist in minor dentoalveolar movements, true skeletal Class II correction may necessitate adjunctive therapies. Correcting Class II malocclusions often involves managing occlusion, controlling overjet, and addressing deep overbites. Aligners, designed for controlled tooth movement, might struggle to exert the precise forces required to modify occlusal relationships and achieve optimal overjet and overbite outcomes.Achieving effective Class II correction might necessitate skeletal anchorage, which aligner therapy might struggle to provide. Correcting Class II malocclusions is often associated with longer treatment durations. Aligner therapy's effectiveness relies on patient compliance, which might wane over extended treatment periods, potentially leading to compromised outcomes.

## CLINICAL EFFECTIVENESS OF CLEAR ALIGNERS

Clear aligner therapy's clinical effectiveness has been evaluated through various studies, shedding light on its outcomes, time efficiency, effects on oral health, post-treatment stability, and potential for root resorption. Studies have assessed clear aligner therapy's effectiveness compared to conventional fixed braces. Djeu et al found both systems equally effective in certain aspects, such as space closure and marginal ridge alignment, but aligners were deficient in addressing anteroposterior discrepancies and occlusal contacts.13 Kassas et al. observed that aligners effectively level and align arches and correct buccolingual inclinations, but might not provide ideal occlusal contacts. Further studies have evaluated tooth movement accuracy, with varying degrees of success in achieving predicted movements.14 Aligner therapy has shown time efficiency advantages in non-extraction cases, with shorter total treatment times and reduced chair time compared to fixed appliances.15 In extraction cases, however, aligner therapy may require more time. Clear aligners facilitate oral hygiene, reducing plaque levels, gingival inflammation, bleeding, and pocket depth. Patients treated with aligners have shown improved oral hygiene and periodontal health compared to fixed appliances.16 Studies evaluating post-retention stability have shown relapse in both aligner and fixed appliance groups. However, more research is needed to comprehensively assess the long-term stability of clear aligner outcomes.17 Root resorption is a concern in orthodontic treatment. Aligners have been associated with lower incidence and severity of root resorption compared to fixed appliances. Incisors tend to show higher susceptibility due to their extensive movement.18

## FUTURE DIRECTIONS IN ALIGNER THERAPY

The future of aligner therapy lies in further integrating advanced technologies. Enhanced software algorithms, artificial intelligence, and machine learning could refine treatment planning, predict tooth movements with greater accuracy, and offer real-time monitoring of treatment progress.19 These advancements could revolutionize treatment predictability and outcomes. Continued developments in 3D printing technology and materials science could lead to the creation of more efficient and customized aligners.20 Innovations in printable materials might offer improved biomechanical properties, allowing for more precise control over tooth movements and root corrections.The customization of aligner treatment could become even more patient-specific.21 Genomic insights, predictive modeling, and individualized treatment plans could lead to aligners uniquely tailored to each patient's genetic profile and treatment needs. Future aligner systems might incorporate advanced compliance tracking mechanisms, such as embedded sensors or wearable devices, to ensure that patients adhere to their prescribed wear schedules.22 Real-time data collection could facilitate better patient management and treatment progress tracking.Remote monitoring and virtual consultations could become integral parts of aligner therapy.23 Orthodontists might remotely assess treatment progress, offer guidance, and make adjustments, enhancing convenience for patients and expanding access to care. As the popularity of aligner therapy grows, long-term stability studies will become more critical.24 In-depth research assessing post-treatment outcomes, stability of results, and potential relapse patterns will provide valuable insights into the durability of aligner treatment effects.Given the rise in environmental awareness, aligner manufacturers might explore eco-friendly materials and sustainable production processes to minimize the environmental impact of aligner therapy.25

## CONCLUSION

Aligners have emerged as a popular and effective alternative to traditional braces in orthodontic treatment. Their discreet nature, convenience, and technological advancements have contributed to their widespread acceptance among patients and orthodontic professionals alike. While aligners have certain limitations, ongoing research and advancements in technology hold the promise of further enhancing their clinical efficacy and expanding their applications in orthodontics.

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