



Treatment Outcomes With Clear Aligners: A Review

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Abstract

Clear aligners have transformed orthodontics, offering a discreet and comfortable alternative to braces, particularly for adults. They excel in treating mild to moderate malocclusions like crowding and spacing, boasting high success rates when patient compliance (20-22 hours daily wear) is maintained. While effective for many cases, their predictability decreases with complex movements such as severe rotations or extrusions, often necessitating auxiliary aids or hybrid approaches. Aligners function through precise, digitally planned force application, with advancements in materials (e.g., SmartTrack®) and AI-driven treatment planning enhancing their capabilities. Patients report high satisfaction due to improved aesthetics, comfort, and oral hygiene. However, limitations include reliance on compliance and challenges with complex 3D tooth movements. Ongoing technological innovations, including 3D printing and remote monitoring, continue to expand their scope, promising more precise and personalized orthodontic care in the future. This article reviews and analyzes the treatment outcomes associated with clear aligner therapy.

Keywords: Clear Aligners, Orthodontics, Patient Compliance, Malocclusion, Treatment Outcomes

Introduction

Clear aligners have brought about a significant transformation in the field of orthodontics, emerging as a preferred alternative to traditional fixed appliances for many patients, particularly adults seeking discreet treatment options. Their rise to prominence began with the introduction of Invisalign® in the late 1990s, which popularized the concept of using transparent, removable plastic trays to gradually move teeth into their desired positions.¹ Since then, the use of clear aligners has grown rapidly, driven by increasing demand for esthetically pleasing, convenient, and comfortable orthodontic solutions. Unlike conventional metal braces, clear aligners offer a number of patient-centric benefits, including improved facial aesthetics during treatment, enhanced oral hygiene due to their removability, and reduced risk of soft tissue irritation.² These factors have contributed to their widespread acceptance, especially among adults and image-conscious adolescents who might otherwise avoid orthodontic care. In addition to being virtually invisible, aligners allow patients to eat, brush, and floss without restriction, further improving their overall treatment experience. Clinical research has extensively evaluated the effectiveness of clear

aligners in achieving desirable orthodontic outcomes.³ Studies have shown that while clear aligners are highly effective in treating mild to moderate malocclusions such as minor crowding, spacing, and some Class I and II discrepancies they may present limitations in addressing more complex orthodontic cases. Tooth movements such as rotation, extrusion, and torque control can be less predictable with aligners compared to fixed appliances. Moreover, successful outcomes are often closely tied to patient compliance, as aligners need to be worn for 20–22 hours per day to deliver optimal results.⁴ Another layer of complexity arises from the fact that not all clear aligners are created equal. While the majority rely on transparent, thermoformed plastic trays to apply force on the dentition, the materials used, the thickness and flexibility of the trays, and the presence or absence of attachments, elastics, and auxiliary components can vary significantly among different brands and systems. These variations influence the aligners' mechanical properties and their ability to correct a broad range of malocclusions.⁵ This article aims to review and analyze the treatment outcomes associated with clear aligner therapy.

Effectiveness and Indications of Clear Aligner Therapy

Clear aligner therapy (CAT) has proven to be a highly effective treatment modality, particularly in cases involving mild to moderate malocclusions. Its primary indications include dental crowding, spacing, minor bite discrepancies, and alignment of anterior teeth. Clinical studies have reported success rates ranging from 80% to 90% in such cases, provided that key factors such as case selection, patient compliance, and the clinician's expertise are appropriately addressed.⁶ CAT has demonstrated significant efficacy in managing anterior-posterior changes in patients with mild Class II malocclusions, especially when used in conjunction with elastics. It is also effective for performing interproximal reduction (IPR) to alleviate mild crowding, and for achieving controlled tipping and bodily movements of the incisors. However, the predictability of clear aligners tends to decrease as the complexity of tooth movement increases.⁷ Movements such as severe rotations—particularly of canines and premolars—vertical movements like extrusion, root torque, and the derotation or distalization of molars are notably more challenging to achieve with aligners alone. These limitations stem from the material properties of the aligners, the absence of rigid anchorage systems found in traditional braces, and the reliance on patient adherence to wearing the trays for the recommended 20–22 hours per day. As a result, in complex orthodontic cases involving significant skeletal discrepancies, deep overbites, open bites, or severe crowding, CAT is often supplemented with fixed appliances or alternative techniques to enhance outcomes.⁸ Rossini et al. (2015) conducted a systematic review which found that the average accuracy of tooth movements with clear aligners was approximately 41%, in contrast to over 70% with conventional fixed appliances. This underscores the importance of realistic treatment planning and setting appropriate expectations for both the clinician and the patient when considering clear aligner therapy for more demanding orthodontic corrections.⁹ Nonetheless, as aligner technology continues to evolve—with improvements in material flexibility, digital treatment planning, and the integration of auxiliaries like attachments and precision cuts—the scope of CAT is steadily expanding, allowing for more reliable and complex interventions than previously achievable.¹⁰

Mechanism of Action and Aligner System Design

Clear aligners function by delivering precise, controlled forces to the teeth through a sequential series of custom-fabricated plastic trays, each slightly different from the last to guide teeth into their desired positions. These trays are developed through advanced digital workflows that include intraoral scanning, 3D modeling, and computer-assisted treatment planning platforms such as ClinCheck®. This digital setup allows clinicians to visualize the entire course of tooth movement, simulate outcomes, and make modifications to improve accuracy and efficiency. Several critical design elements influence the efficacy of clear aligner therapy, including the type and properties of the thermoplastic material used, the incorporation of attachments (small tooth-colored composite “buttons”) that enhance grip and facilitate complex movements, the careful staging of movements to control forces incrementally, and the use of auxiliary aids such as elastics or mini-implants to manage anchorage or achieve vertical control. Patient compliance is an essential determinant of success, as aligners must be worn for at least 20 hours per day to produce the intended forces consistently.¹¹ Moreover, successful outcomes with clear aligners require

in-depth clinical knowledge of orthodontic biomechanics, accurate diagnosis, and meticulous treatment planning. If teeth tip more than 5 degrees during space closure, fixed appliances may become necessary to achieve optimal alignment, and tipping beyond 10 degrees often warrants full fixed appliance therapy or a hybrid approach incorporating fixed elements. Nelson and colleagues have emphasized various advantages of aligner software tools, which support diagnosis and planning by evaluating the need for interproximal reduction (IPR), expansion, extractions, or movements such as distalization and proclination.¹² These platforms also facilitate monitoring of aligner tracking, assessment of anchorage using superimposition or surgical simulation features, and communication with patients using visual aids to explain treatment limits. Additionally, aligning the patient's chief concern—typically anterior teeth—early in the series and incorporating simultaneous movements where appropriate can reduce the total number of aligners needed. Collectively, the integration of sophisticated digital tools, mechanical aids, and biomechanical principles forms the foundation for effective and efficient treatment with clear aligners.¹³

Treatment Duration, Efficiency, and Patient Satisfaction in Clear Aligner Therapy

Clear aligner therapy (CAT) has demonstrated notable advantages in terms of treatment efficiency and patient satisfaction, particularly in cases of mild to moderate malocclusion. One of the primary benefits of aligners is the reduced chair-side time, largely due to the absence of common emergencies such as broken wires or brackets, which are frequently encountered with fixed appliances. In terms of overall treatment duration, aligners have been shown to produce significantly shorter treatment times—typically ranging from 3 to 6 months—for non-extraction mild cases when compared to traditional braces, making them a preferred option in such scenarios.¹⁴ However, in more complex cases, especially those requiring premolar extractions or involving skeletal discrepancies, fixed appliances generally result in faster treatment completion and remain the system of choice. Patient compliance plays a critical role in the success and efficiency of CAT, as optimal outcomes rely on wearing the aligners consistently for 20 to 22 hours per day. Attachments, or small composite elements bonded to the teeth, are essential components that enhance the aligners' ability to perform complex movements. The design, material, and strategic placement of these attachments significantly influence treatment precision and effectiveness, particularly in challenging cases (Demir, 2024).¹⁵ Studies also report that clear aligners offer treatment outcomes comparable to those achieved with conventional braces, with the added benefit of improved patient comfort and esthetic appeal, factors that contribute to higher satisfaction levels (Bhagwan et al., 2024; Muthulakshmi et al., 2025). Furthermore, moderate-quality evidence indicates that clear aligner therapy is more time-efficient in clinical settings, requiring fewer follow-up visits and significantly less chair-side adjustment time—estimated to be about 93.4 minutes less per patient, along with approximately 7 minutes saved in emergency appointments. These efficiency gains, coupled with positive patient-reported outcomes, reinforce the value of CAT as a reliable and patient-friendly orthodontic option, particularly when appropriately matched to case complexity.^{16,17}

Case Selection, Complexity, and Patient-Centered Outcomes in Clear Aligner Therapy

Careful case selection is essential to achieving successful outcomes with clear aligner therapy (CAT), as its effectiveness varies depending on the complexity of the malocclusion and patient compliance. Clear aligners are ideally suited for treating Class I malocclusions associated with mild to moderate crowding or spacing, particularly in patients who seek a discreet and comfortable orthodontic solution. They are also effective for mild Class II corrections when used in conjunction with elastics, and are often preferred in patients with periodontal concerns due to their superior facilitation of oral hygiene and reduced plaque accumulation.¹⁸ However, the utility of aligners diminishes as the case complexity increases. In more advanced cases—such as severe Class II or Class III malocclusions, open bite or deep bite corrections, and situations requiring significant tooth movements or premolar extractions—CAT may fall short in achieving precise control over buccolingual inclination and occlusal contacts, as noted by Jaber et al. (2023). In such instances, hybrid approaches combining fixed appliances with aligners, or even full fixed appliance treatment, may be required to ensure optimal results. Additionally, clear aligners are not well-suited for patients with poor compliance, as the success of treatment is highly dependent on wearing the aligners for 20–22 hours per day.¹⁹

Clear Aligners and Periodontal Health

Clear aligners, developed through advanced digital technologies, offer a removable orthodontic solution that not only addresses malocclusion but also promotes better periodontal health compared to traditional fixed appliances. One of the key advantages of clear aligner therapy is its ability to facilitate superior oral hygiene by minimizing plaque accumulation, reducing gingival inflammation, and lowering the risk of white spot lesions.²⁰ Their removable nature allows patients to maintain regular brushing and flossing routines without the hindrance posed by brackets and wires, which are common in fixed appliances. Studies consistently show that patients undergoing treatment with clear aligners tend to exhibit improved periodontal outcomes, particularly in cases of mild to moderate periodontal disease. The aligner design—with its smooth, clear plastic splints that cover the teeth and marginal gingiva—minimizes gingival irritation while gradually guiding teeth into ideal positions through carefully planned 3D movements. However, while aligners are effective in maintaining periodontal health, their use in patients with severe periodontal disease must be approached with caution due to the inherent risks associated with active periodontal breakdown. Most existing research focuses on young individuals with healthy gums, yet studies by Low et al. and Levrini et al. have shown that the microbial biofilm formed on aligners—especially along textured or elevated edges—tends to contain bacteria with low pathogenicity for periodontal disease, further supporting their safety. Additionally, the reduced number of plaque-retentive surfaces and the design of aligners contribute to easier cleaning and lower plaque retention compared to fixed appliances. Overall, when combined with proper oral hygiene education and regular monitoring, clear aligners appear to be a safe and effective orthodontic option even for patients with compromised periodontal health, making them an increasingly valuable tool in interdisciplinary periodontal-orthodontic treatment planning.²¹

Limitations and Challenges of Clear Aligner Therapy

Despite the growing popularity and widespread use of clear aligners in orthodontic treatment, several limitations and challenges continue to impact their universal applicability and clinical predictability. One of the foremost challenges is the heavy reliance on patient compliance. Since aligners are removable, patients must wear them consistently for 20 to 22 hours per day to ensure effective tooth movement. Non-compliance can lead to suboptimal results, delayed progress, or the need for additional refinements. Furthermore, clear aligners often struggle with executing complex three-dimensional tooth movements, such as extrusion, significant rotations, and precise root torque control.²² These limitations frequently necessitate the use of auxiliary devices like elastics, mini-screws, or even hybrid approaches involving partial fixed appliances. Another concern is the potential for under-correction, which may require mid-course adjustments or additional refinement aligners, thereby extending the treatment duration. The cost of clear aligner therapy can also be prohibitive for some patients, as it is often higher than traditional braces, particularly when multiple refinement stages are needed. From a research standpoint, variability in study design, patient populations, and outcome measures makes it difficult to generalize findings or establish consistent treatment guidelines.²³ Moreover, most available evidence focuses on short- to mid-term results, with limited data on the long-term stability of outcomes achieved through clear aligner therapy. Additionally, many studies rely on self-reported measures of compliance and satisfaction, which may introduce bias and overestimate success rates. These limitations highlight the importance of careful case selection, realistic patient education, and the clinician's proficiency in biomechanical principles and digital treatment planning. While technological advancements continue to enhance the scope and precision of aligner therapy, clear aligners are still best utilized in appropriately selected cases, with transparent discussion of their strengths and limitations.²⁴

Advancements in Clear Aligner Technology and Future Potential

In recent years, clear aligner therapy has undergone significant technological advancements that have expanded its clinical capabilities, improved treatment precision, and enhanced the overall patient experience. One of the most notable developments is the introduction of SmartTrack® material, a proprietary thermoplastic engineered to offer greater elasticity, optimal force delivery, and better retention compared to earlier materials. This has led to more consistent and predictable tooth movements, especially in complex treatment stages. Another major innovation is the integration of artificial

intelligence (AI) into treatment planning software, allowing for more accurate simulations, optimized staging of tooth movements, and real-time adjustments based on individual patient data. AI-driven platforms are increasingly aiding clinicians in diagnosing malocclusions, forecasting outcomes, and customizing aligner designs with enhanced biomechanical efficiency. The adoption of 3D printing technology has also revolutionized aligner manufacturing, enabling faster and more precise in-office fabrication of aligners. This not only reduces turnaround time but also offers greater flexibility for mid-course corrections. Moreover, the rise of remote monitoring tools and mobile applications has improved patient compliance by allowing orthodontists to track progress digitally, minimizing the need for frequent in-person visits and enabling timely interventions if treatment is off track. Emerging innovations, such as directly printed clear aligners, have demonstrated promising results in managing Class II malocclusions and dental crowding, offering both functional and esthetic improvements. These next-generation aligners eliminate the need for molds and thermoforming, reducing manual error and production time. According to recent studies (e.g., Viet et al., 2024), such systems have shown effective results in enhancing dental alignment and facial profile correction.¹⁰ Additionally, continued improvements in 3D software, digital workflow integration, and material science are expected to expand the indications for clear aligner therapy to include more complex orthodontic cases. As highlighted by Muthulakshmi et al. (2025), the future of aligner therapy lies in the seamless convergence of AI, digital design, and bioengineered materials, which will likely redefine treatment possibilities, elevate outcome predictability, and offer a truly personalized orthodontic experience.^{16,25}

Conclusion

Clear aligners offer a discreet, effective, and patient-friendly orthodontic option, especially for mild to moderate malocclusions. They provide comparable results to traditional braces for select cases, with added benefits of improved oral hygiene and patient satisfaction. However, limitations remain for complex movements and long-term stability data is still evolving. Patient compliance and careful case selection are critical to achieving optimal outcomes.

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