

## Review Article

### Clear aligners in orthodontic tooth movement: A conceptual review

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#### ABSTRACT:

In recent years, the importance of appearance in personal and professional lives has prompted a rise in adult patients seeking orthodontic treatment. Clear aligners, is a new generation of aesthetic orthodontic treatment options designed specifically for adults who are self-conscious about their appearance. This article is to detail history, various generations of aligners, biomechanics, advantage, disadvantage, factors affecting OTM with clear aligners

**Key words:** Clear Aligners; Aesthetics; Computer Aided Design and Manufacture

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#### INTRODUCTION

As the number of adults seeking orthodontic treatment has increased, so has the interest for appliances that are both more aesthetically appealing and more comfortable than traditional fixed equipment<sup>1</sup>. ClearAligner Therapy (CAT) encompasses a wide range of applications with varying modes of action, construction methods, and applicability to various malocclusion therapies. All utilize clear thermoformed plastic aligners to cover many or all of the teeth, but there are significant variances that affect each system's capacity to treat a wide range of orthodontic problems. Initially, CAT was only used to treat minor tooth position irregularities. Some aligner systems are specifically designed to correct minor positional irregularities, while others claim to be able to correct complex malocclusions. Published clinical data supporting such assertions is either non-existent or falls well short of high-level scientific evidence. Despite the fact that these appliances have been on the market for over 15 years and have experienced continual development and adjustment, there is very little clinical research on how they achieve their benefits. In 1993, Sheridan established a unique method that integrates clear aligners with interproximal reduction (IPR), resulting in modest tooth movement. The major downside to this approach is that it needs a newer impression for every patient visit. To meet the growing demand for aesthetic treatment,

Align Technology launched Invisalign TM in 1998. In align technology, they used varied stereolithography techniques and they initiated the use of CAD/CAM technology in the field of orthodontics, scanned pictures are converted to physical models, and a set of removable polyurethane aligners are created to consecutively reposition a tooth or a small group of teeth in the range of 0.25 to 0.33 mm with a 14-day interval.

In the view of construction material, production process, margin finishing and STL model precision, many aligner systems differ from Invisalign, yet the most distinct change is the professionals in charge of treatment planning and setup (IT specialists, dental technicians, or professional orthodontists). Major constraint related to clear aligner therapy is lack of efficacy, treatment outcome in treating different types of tooth movement are buccolingual inclination (torque), interocclusal sagittal changes, overjet, closure of extraction spaces, occlusal contacts and expansion in comparison to the traditional fixed appliance.

The purpose of this article is to detail history, various generations of aligners, biomechanics, advantage, disadvantage, factors affecting OTM with clear aligners.

#### HISTORY

When Kesling developed a tooth positioning appliance to optimise the final stages of orthodontic

therapy in the 1940s, the principle of utilising an aligner to straighten teeth was first proposed (Kesling, 1946)<sup>2</sup>. CAT is a natural progression from the usage of teeth positioners, which were initially introduced by TP Orthodontics in 1945, and spring aligners for tooth alignment, which have been used by orthodontists for decades. These concepts were further refined by Nahoum<sup>3</sup> Ponitz<sup>4</sup>, McNamara<sup>5</sup>, Sheridan<sup>6</sup>, and Truax<sup>7</sup> before being recently integrated with breakthroughs in transparent thermoplastic materials and computer technology (CAD-CAM, stereolithography and tooth-movement simulation software). Clear aligner (CA) products have become increasingly available and effective for teeth alignment in a variety of malocclusions as a result of this. This positioner was a pliable rubber item made from a wax up of the teeth in a class I occlusion in a laboratory (Phan and Ling, 2007). Minor tooth movements were possible with this appliance while the remaining teeth in the arch were kept in alignment. Tooth control was difficult, and crown tipping was the only alternative.

## **ALIGNER GENERATIONS**

### **FIRST GENERATION**

The results of the early versions of these systems were purely dependent on the aligner. Auxiliary elements were not included. There is a paucity of research on the tooth movements achieved by these aligners. Djeu et al. 2005<sup>8</sup> compared their first 48 Invisalign patients to a group of fixed appliance patients. They assessed the results achieved by the various treatment regimens using the American Board of Orthodontics objective grading system. Invisalign and fixed appliances produced equivalent results in two categories: marginal ridge alignment and root angulation. Fixed appliances, on the other hand, got significantly better results in the areas of buccolingual inclination, occlusal contacts, occlusal relationship, and overjet reduction.

### **SECOND GENERATION**

Manufacturers began to encourage the use of attachments to increase tooth movement as aligner systems evolved. Clinicians could ask for composite buttons to be placed on teeth, as well as the usage of inter-maxillary elastics.

Kravitz et al. (2008, 2009) evaluated the accuracy of tooth movements caused by these newer aligners in two different investigations. They compared the virtual tooth movements predicted by tooth movement software to the clinical results produced by aligners, aligners with attachments, or aligners with interproximal reduction in a prospective clinical research (Kravitz et al., 2008). Anterior Invisalign aligners were used to correct 51 rotated canines.

When compared to the expected results, the average accuracy of derotation attained was 35.8% (Kravitz et al., 2008). The patients who received attachments and

interproximal reduction had similar results to those who received only aligners (Kravitz et al., 2008).

### **THIRD GENERATION**

In two independent investigations, Kravitz et al. (2008, 2009) attempted to change the way aligner appliances produce force in order to improve results and obtain better control of tooth movements with aligner appliances. Where extrusions, derotations, and root movements are required, the manufacturer's software now places attachments automatically. Where root torque is required, indentations in the aligners are produced. Non-precision attachments can also be requested to be placed on the teeth where the operator believes they will improve the movements. There are three common types of attachments: ellipsoid, bevelled and rectangular. When all three types of attachments are bound to the tooth, they are not entirely engaged at first. The attachments become increasingly active as the patient progresses through the successive aligners, until they completely fill the aligner slot. When employing the preadjusted edgewise appliance, this technique is equivalent to operating through archwires. When lingual root torque is necessary for maxillary or mandibular incisors, indentations are made in the aligners. They're indentations in the polyurethane that raise pressure on specific spots on the crown, causing MoC and torquing the root. No research is available to verify that recommended tooth movements have been accomplished.

### **VARIETY**

1. Minor tooth movement (MTM) with limited clinical applicability
2. Direct to Consumer Alternatives
3. Make Your Own Aligners
4. Complex, Comprehensive Systems

### **BIOMECHANICS OF ALIGNER TREATMENT**

Understanding the mechanics of tooth movement using aligners could lead to better patient selection and treatment sequencing, resulting in improved outcomes.

The displacement driven system and the force driven system can both be used to explain the tooth movement mechanism with clear aligners. Simple movements like tipping or slight rotations are mostly controlled by the displacement driven method. Aligners are made to match the position of the tooth in the next staged location, and the tooth moves until it aligns with the aligner. This technique has been shown to be ineffective in controlling tooth movement and in creating root motions. To promote tooth movement, the force-driven system, on the other hand, requires biomechanical principles. Aligners are made to exert specific stresses on the teeth. The shape of the aligners used to generate these forces isn't always the same as the shape of the tooth. Clincheck® (Align Technology, Santa Clara, CA,

USA) programme determines the movement required for each individual tooth, the mechanical principles used to produce this movement, and the aligner form. Pressure points or power ridges are used to change the geometry of the aligner in order to apply the required forces. Pressure points make uprighting and intrusion motions more difficult, but power ridges regulate axial root movements and torque. Despite the changes in aligner design, root paralleling, extrusion, and rotation were difficult to achieve with aligners until Align Tech. (Align Technology, Santa Clara, CA, USA) released smart force attachments for the Invisalign® system. These attachments are little composite bulges that create a force system that is conducive to the intended movement. Clincheck® software determines their position and shape according on the movement to be obtained.

### **ADVANTAGES**

Traditional fixed-appliance orthodontic treatments have some advantages that CAT does not. Fewer clinical emergencies, increased aesthetics, comfort, and oral hygiene, periodontal health, and a lack of soft tissue irritation are just a few of the benefits.

**EMERGENCY-** In CAT, there are very few crises. In most cases, lost or damaged aligners can be replaced within two weeks while the patient continues to wear the previous aligner<sup>9</sup>.

**COMFORT-**The pain and discomfort of CAT was compared to that of fixed appliances in the first week of treatment. Furthermore, as compared to fixed appliances, the aesthetics, removability, and compact size of Invisalign aligners resulted in superior functional and psychosocial differences, as well as significantly reduced pain<sup>10</sup>.

**AESTHETICS-**Aesthetic concerns have been proven to be a key reason for CAT<sup>11</sup>.

**PERIODONTAL HEALTH-**The use of CAT in the treatment planning of adult orthodontic patients at risk of periodontitis has been advocated. When compared to fixed orthodontic appliances, CAT was found to be related with improved periodontal condition and lower levels of bacteria after a 12-month trial period<sup>12</sup>.

### **DISADVANTAGE**

Even though clear aligners are removable, patients must be more motivated to attain the desired results. These devices must be worn for a total of 22 hours every day.

Clear aligners must be taken out during meals, while consuming hot drinks that could cause deformation, sugary drinks, and when brushing your teeth.

Treatment time may be extended due to patient compliance with dentist's instructions, not wearing aligners for the required number of hours per day, missed appointments, poor oral hygiene, and broken appliances. These factors can increase treatment time, cost, and thus affect the quality of the final results.

### **CLINICIANS SHOULD CONSIDER WHEN EVALUATING A CAT SYSTEM**

1. Is vacuum-forming or pressure-forming used to make aligners? In most cases, pressure-forming is linked to better aligner fit.
2. Is there a limit to how many aligners a case can have? Products that limit the intricacy of the malocclusion that can be treated primarily do so by limiting the number of aligners produced for a given patient.
3. Is there any additional case complexity that the aligner product can't handle, according to the manufacturer?
4. Is the aligner product equipped with integrated bonded attachments, as well as specialised aligner shape changes (pressure points, power ridges, bite ramps, elastic cut-outs, and so on)? The more complex the movement that can be treated with confidence, the more advanced the spectrum of available aligner auxiliaries.
5. The need for the aligners to cover the gingiva is a question that has yet to be answered definitively. In the absence of tooth-borne attachments, gingival covering is necessary to increase aligner retention, but it is possibly less hygienic and necessitates more impression/scan detail.
6. Is all of the aligners in a CAT system made of the same material, or is material variety important for moving teeth?
7. Is it better to make the aligners with a stone model, an impression, or an intraoral scan? For aligner manufacturing and fit, intraoral scans are the most accurate.

### **FACTORS AFFECTING OTM WITH CLEAR ALIGNERS**

OTM can be influenced by patient variability. Age, sex, root length, bone levels, bone density, medications, and certain systemic disorders can all hinder, synergize, or enhance to the effects of OTM. Medications with pharmacologic effects may have an influence on the OTM cells. Bisphosphonates, estrogens, NSAIDS and other analgesics, corticosteroids, calcium regulators, and supplements are only a few of the pharmaceutical types.

OTM has been reported to be affected by systemic causes or nutritional deficiencies that impact bone metabolism. Bone diseases, in particular, can have a considerable impact on the rate of tooth movement. Osteopetrosis is a disorder characterised by sclerosis of the bone and limited tooth movement and eruption due to reduced or full deficiency of osteoclast function. Paget's disease, on the other hand, is characterised by unregulated bone turnover caused by osteoclast overactivity<sup>13,14</sup>. Although OTM causes an inflammatory response in the periodontal ligament and adjacent tissues, any chronic inflammatory illness, such as thyroiditis, asthma, or allergies, is thought to influence tooth movement<sup>15,16</sup>. Actual

tooth movement using aligners was compared to predicted movement during the course of therapy by Kravitz et al. Aligner therapy is already a routinely prescribed treatment for OTM in adolescents and adults, and a better understanding of movement patterns and factors that influence movement could lead to more effective treatment<sup>17</sup>. McGorray et al used this model to study the weekly pattern of tooth movement during an 8-week period, as well as subsequent relapse<sup>18</sup>.

## CONCLUSION

In recent years, transparent aligners have expanded their indications and efficiency by diversifying and evolving their primary characteristics (material, gingival margin design, attachments, divots, auxiliaries). In orthodontics, clear aligner treatment is becoming widely attractive. A deeper knowledge of how tooth movement is accomplished could lead to more effective treatments.

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