ISSN No:-2456-2165

# Clear Aligner Therapy- New Vistas in Orthodontics

Sachin Philip[1] ; Varun Goyal[2] ; Gurkeerat Singh[3] ; Sridhar Kannan[4] ; Raj Kumar Singh[5] ; Ankit Chaudhari[6]
Sudha Rustagi College of Dental Sciences and Research

**Abstract:- In the last two decades, advances in digital and 3D printing technology, a rise in interest in cosmetic orthodontics, particularly among adults, and manufacturer marketing on a global scale have all contributed to clear aligners becoming a staple in modern orthodontic practise. Clear aligners have seen numerous improvements since they were first introduced with the goal of making orthodontic treatment less obvious. Like many other orthodontic tools, transparent aligners are used to move teeth for alignment and to create healthy, attractive smiles, but they are far more comfortable and aesthetically pleasing. The success of the treatment depends on the therapists' expertise and experience with the aligners, careful case selection, and patients' adherence to the prescribed treatment plans.**

***Keywords:-*** *Clear Aligner Therapy, Invisalign, Treatment Effects, Aligners.*

## I. INTRODUCTION

Clear aligners have indeed become an increasingly popular alternative to fixed appliance treatment for mild to moderate malocclusions. The concept of clear aligners has a long history starting with Kesling who refined the final stages of orthodontic treatment with tooth positioners[1]. In 1971, Ponitz[2] introduced the "invisible retainer", which inspired similar appliances by McNamara and Sheridan[3]. The development of CAD and Rapid Prototyping techniques (Rapid prototyping is a process that involves creating a physical model of a product or design quickly and efficiently. In the context of aligner making, rapid prototyping can be used to create prototypes of aligners for testing and evaluation purposes) allowed an industrial approach to planning orthodontic treatment and manufacturing polymeric aligners[4,5]. In 1998, Align Technology introduced Invisalign®, a series of removable polyurethane aligners, as an aesthetically appealing alternative to fixed labial braces.

These aligners are custom-made to fit over the patient's teeth and gradually shift them into the desired position over time[6]. However, in recent years, the system has evolved significantly with the introduction of auxiliaries, attachments, and higher fabrication materials, permitting aligners to provide a extra variety of range of motion in much less time. Despite the increasing professional use of clear aligners, questions remain regarding their efficacy, particularly for complex malocclusions[7]. Studies have shown a consistent mismatch between predicted and clinical outcomes, with a discrepancy of around 50%. This requires multiple stages of refinement or added treatment, and many orthodontists report that 70% to 80% of their patients require midcourse correction, case refinement, or conversion to fixed appliances earlier than the quit of the treatment[8]. Additionally, patients treated with clear aligners have shown more relapse than those treated with fixed appliances, particularly for the maxillary anterior teeth[9].

In summary, while clear aligners have become a popular alternative to fixed appliance treatment, their efficacy for complex malocclusions remains a subject of debate. The development of new materials and techniques has improved the range of movement that can be achieved with aligners, but their limitations should be carefully considered when selecting an orthodontic treatment option.

Clear Aligners were primarily used to treat minor tooth position irregularities, and treatment outcomes were inconsistent. However, with the introduction of Invisalign in 1998, the field of clear aligner therapy has seen significant development and advancement[6]. There are various types of clear aligners, and they differ in terms of their construction method, material, and applicability to different malocclusion therapies[10]. CAD/CAM technology and 3D printing have also revolutionized the manufacturing process of aligners, resulting in more precise and accurate aligners[4,5].

The biomechanics of clear aligners are quite different from those of traditional fixed braces. The amount of force applied to the teeth is generally less than that of traditional braces, but the duration of treatment may be longer. The key to successful clear aligner treatment is consistent wear of the aligners, typically for 20-22 hours per day[11].

While clear aligners offer many advantages over traditional braces, they also have some disadvantages. One major constraint related to clear aligner therapy is the lack of efficacy in treating complex malocclusions, such as severe crowding or skeletal discrepancies. Treatment outcomes for clear aligners has a higher risk of relapse after treatment[12].

Factors that can affect the effectiveness of clear aligner therapy include the type and severity of the malocclusion, the patient's age and compliance with treatment, and the skill and experience of the orthodontist or dental provider. It is important for patients and doctors to carefully consider the pros and cons of clear aligner therapy and consult with an experienced orthodontist or dental provider to determine the most appropriate treatment option for their individual needs[13].

ISSN No:-2456-2165

## II. HISTORY

Dr. Kesling was the first to use flexible tooth positioners to move teeth in 1945. Later, in 1964, Nahoum introduced vacuum-formed dental contour appliances followed by Ponitz's "invisible retainer" in 1971. McNamara introduced invisible retainers in 1985[1-3]. These ideas were combined by Align Technology, Inc. To create Invisalign® in 1998. Invisalign® uses CAD-CAM technology to create custom appliances that are aesthetic, removable, and can move teeth. Invisalign® was developed by Kelsey Wirth and Zia Chishti, who received assistance from Robert Boyd, chairman of the Department of Orthodontics, University of the Pacific. Align Technologies received FDA clearance in 1998 and began commercial operations in 1999[14].

Clear path, founded in 2008, introduced USFDA-approved aligners using a unique proprietary process for correcting malocclusion. Clear correct was also founded in 2006 and received FDA approval in 2009. Inman Aligners, which use super elastic open coil springs to create light and constant forces on both the labial and lingual surfaces of anterior teeth, were introduced as a unique modification of traditional spring retainers. Airnivol aligners were introduced by NIVOL in close collaboration with the University of Pisa in Italy in 2010. Novo align, conceptualized in the US in 2016, uses a team of orthodontists, engineers, dental technicians, and IT professionals to create custom aligners made of USFDA approved medical-grade flexible plastic material[15].

Recently, 3M oral care announced the entrance of 3M Clarity aligners into the clear aligner sector. Dr. Neil Warshawski used the evaluation and remedy making plans gear in 3M oral care portal to deal with relapse of anterior teeth the usage of those aligners.

## III. BIOMECHANICS

By understanding how tooth movement works with aligners, it is possible to choose the right patients and treatment plan for better results. There are two main perspectives to explain tooth movement with clear aligners: the displacement driven system and the force driven system. The displacement driven system is less effective and only controls simple movements such as tipping or minor rotations. Aligners are designed based on the position of the tooth in the next stage, and the tooth moves until it lines up with the aligner. The force driven system, on the other hand, requires the application of biomechanical principles to facilitate tooth movement[16]. Aligner-based orthodontic treatment involves moving teeth gradually with a series of aligners, each one repositioning the teeth slightly[17].

There are two primary mechanisms for achieving this: **the shape molding effect** and the use of auxiliary elements such as attachments and **power ridges**[18]. The shape molding effect is the primary means of force application in clear-aligner treatment. It involves molding the movement of the teeth to the shape of the aligner used. The aligner's shape is designed to create pre-established mismatches with the dental crown geometry, generating 3D force systems distributed all over the contact surfaces. This results in areas of intimate contact and relief between the aligner and the tooth surface.

A full treatment consists of a set of aligners with sequentially varying shapes, moving from the initial anatomic geometry to the final tooth positions.

Auxiliary elements such as attachments and power ridges can be strategically arranged in aligners or on the teeth to enhance predictability of specific tooth movements. They are used to deliver forces at specific areas on the tooth surface. **Smart force attachments** were later introduced to help with movements such as root paralleling, extrusion, and rotation. While extrusion of a single tooth is moderately difficult with clear aligners, auxiliaries such as buttons and elastics can be used to facilitate the movement, and the extrusion of a group of teeth can be performed. The use of temporary anchorage devices (tads) in combination with clear aligners has expanded the range of treatments that can be accomplished with aligners.

## IV. BIOLOGY OF TOOTH MOVEMENT

At the fundamental level, tooth movement is the result of the interplay between the appliance and the biological complex consisting of the periodontal ligament and surrounding bone. To achieve tooth movement, an aligner must maintain acceptable levels of stress (optimal force) throughout treatment. Theoretically, the stress exerted by the shape molding effect is significantly lower than the stress created via an attachment for the same force system[19]. The shape molding effect used in Invisalign treatment involves applying forces to a larger surface area of the tooth, which allows for more efficient movement compared to the use of attachments. Attachments are small, tooth-colored bumps that are attached to the teeth to provide additional leverage and control during the alignment process. However, the surface area of an attachment is much smaller than that of the tooth itself, which can limit the effectiveness of the forces applied.

The shape molding effect, on the other hand, allows for a more even distribution of forces across the tooth's surface, which can lead to more predictable and efficient movement[20]. However, most of the treatment is executed through the shape molding effect. The **"watermelon seed effect"** refers to the ability of Invisalign aligners to apply compressive forces from all directions to the teeth. This is due to the aligners' ability to engage the occlusal (biting surface), buccal (outer surface facing the cheek), and lingual (inner surface facing the tongue) surfaces of the teeth simultaneously[21]. This 360-degree contact allows for a more even distribution of force across the tooth's surface, which can lead to more effective and efficient movement. To address this issue, certain modifications called **"pressure areas"** can be added to the aligners to create an additional force that will redirect the net compressive force through the center of resistance.

Deep-bite correction can also be achieved by extrusion of posterior teeth, which is done by removing occlusal forces. Invisalign treatment may involve the use of bite ramps or lingual prominences to help disocclude (separate) the posterior teeth and encourage extrusion (movement out of the gum tissue) of the anterior teeth. These bite ramps or prominences are small, raised areas that are added to the palatal (upper) surface of the maxillary (upper) incisors or canines near the cingulum (the raised area on the lingual surface of the tooth)[22]. When the patient bites down, these ramps or prominences contact the lower teeth and disocclude the posterior teeth. This can help to create space for the anterior teeth to move and encourage them to extrude. Bite ramps and lingual prominences are examples of the various attachments or features that can be added to Invisalign aligners to enhance the treatment and achieve the desired results.

The **"drawbridge effect"** is a term used to describe the pseudo correction of an overbite that can occur when only the anterior teeth are tipped forward during Invisalign treatment. "Power ridges" can be added to the gingival third of the crown on aligners to enhance the tipping of incisors[23]. Open-bite correction is essentially the reverse of deep-bite correction, where anterior teeth need extrusion instead of intrusion and posterior teeth need intrusion instead of extrusion.

The intrusion (downward movement) of posterior teeth during Invisalign treatment can result in a forward and counterclockwise rotation of the mandible (lower jaw). This movement can help to reduce an open bite, which is a condition where the upper and lower front teeth do not touch when the back teeth are closed together. By intruding the posterior teeth, the occlusal (bite) plane is altered, and the mandible is rotated forward and counterclockwise, allowing the front teeth to meet when the back teeth are closed together[24]. This can improve the patient's bite function and aesthetic appearance. The combination of drawbridge effect and autorotation of the mandible caused by posterior teeth intrusion accounts for most of the correction observed, with true extrusion of anterior teeth contributing only a small portion[25]. Optimized root control attachments and power ridges establish second-order and third-order control over tooth movement, respectively.

Torquing of roots is perhaps the most force-intensive type of tooth movement in orthodontics. Root movement with aligners has been challenging and requires higher magnitudes of force sustained through the entire movement[26]. Invisalign® are designed to apply desired forces on the tooth using Clincheck® software which are proprietary software of Invisalign to determine the movement required for each individual tooth and the aligner shape. The shape of the aligner is altered using pressure points or power ridges to control movements such as axial root movements and torque[27].

➢ *Advantages of Aligner Therapy[27,28,29]:*

- *Adult patients with esthetic considerations*
- *Reluctant to conventional fixed appliances*
- *Easy Oral hygiene facilitation*
- *Comparatively less pain*
- *Decreased number and duration of appointments*
- *Decreased Need of emergent visits.*

➢ *Disadvantages[27,29]:*

- *Expense in production*
- *Dependency on patient cooperation*
- *Inability to treat certain malocclusions*

➢ *Classification[5,12]:*

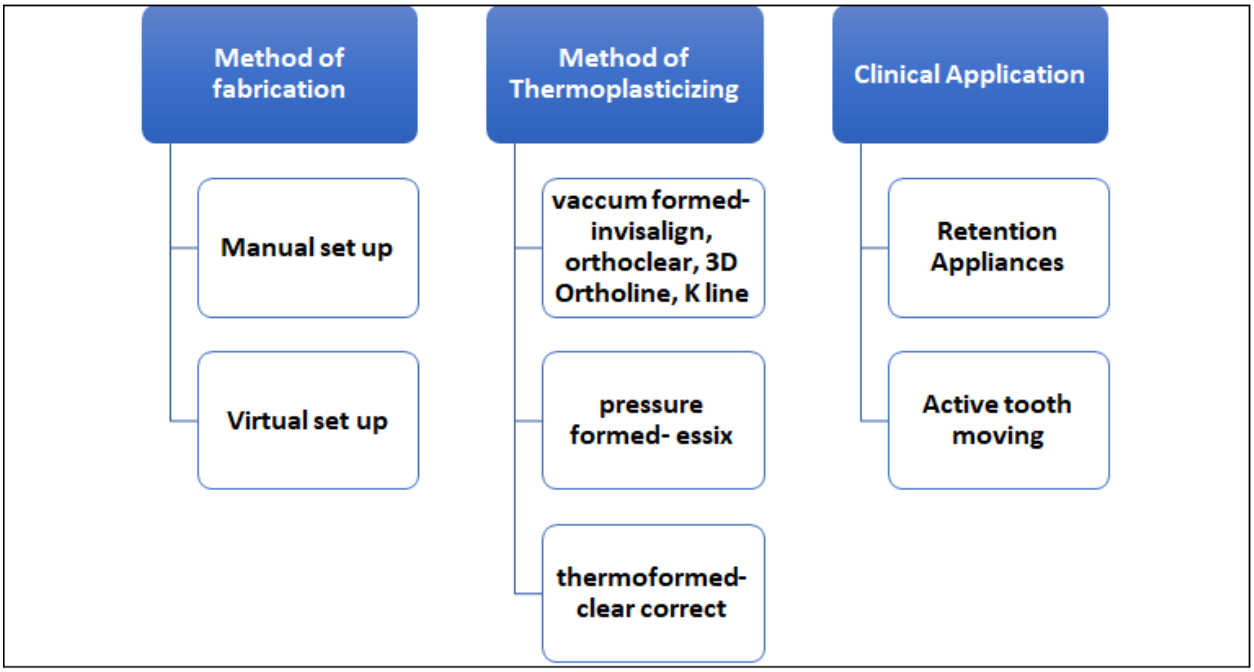


Fig 1 Classification[5,12]

ISSN No:-2456-2165

➢ *Procedures:*

The treatment process for orthodontic aligners typically begins with a thorough evaluation and diagnosis by a dentist or orthodontist, including X-rays, photographs, bite registration, and dental impressions. These records are used to create a digital 3D model of the teeth and gums. Using specialized software, technicians then move the teeth to the desired position, creating a series of aligners that gradually shift the teeth into place. The number of aligners required can vary from six to 48, depending on the specific needs of the patient. Once the treatment plan has been finalized and approved by the doctor, the digital model is transferred to a cast, and clear plastic aligners are formed over each cast. The set of aligners is then sent to the doctor to be given to the patient to begin the treatment process[30].

➢ *Indications*:

- *Fully erupted permanent teeth.*
- *Mild to moderate spacing or crowding issues. It can also be used for Narrow arches that are dental in origin,*
- *Cases with relapse, and*
- *tooth movement following interproximal reduction,*
- *Flaring of upper and lower incisors, distalization of teeth*
- *Space closure after the extraction of a lower incisor.*

However, the literature suggests that Invisalign is most effective for Class I malocclusions and mild spacing/crowding issues. It may be less effective than traditional orthodontic treatment in some cases. Therefore, it is important to carefully evaluate each patient's specific needs and consider all treatment options before deciding whether Invisalign is the best choice for them[31].

## V. FACTORS CONSIDERATION

- To achieve successful results with Invisalign treatment, it is important that the patient is highly cooperative and committed to wearing the aligners as instructed. The aligners must be worn for a minimum of 20 hours per day, seven days a week, to achieve optimal results[32].
- Successful clear aligner treatment requires a high level of clinical expertise in orthodontics, as well as proper diagnosis, treatment planning, and knowledge of biomechanics.
- In some cases, the teeth may tip more than 5° during space closure, which may require fixed appliances to upright them properly.
- If the tipping exceeds 10°, a fixed appliance segment may need to be incorporated to upright the teeth or the treatment may need to be converted to full fixed appliances to achieve the desired results[33].
- The aligner software has several advantages, including the ability to aid in diagnosis and treatment planning, verify modifications made by the technician, show treatment limits to the patient, evaluate anchorage and staging, and address the patient's chief concern at the beginning of the treatment to reduce the overall number of aligners needed.

## VI. CONCLUSIONS

In modern orthodontics, the indications and the efficiency of the clear aligners have been expanded and evolved widely. Clear aligners are not only hugely attractive because of the aesthetic appearance but also due to the least discomfort experienced by the patient. Orthodontists learned about clear aligners mostly during academic seminars, congress lectures and papers or books in comparison to general dentists. Along with the above mentioned, the other benefit is that the patients has the opportunity to see the end result of finished stage of the treatment. The vast innovations in the aligner material has brought about radical changes in its application.

Flexible removable appliances have rapidly evolved, but currently, they are not as efficient as fixed appliances in treating malocclusions, especially complex cases. One of the main drawbacks of removable appliances is that they rely on patient compliance. However, new compliance detectors aim to overcome this limitation, and as technology advances, these appliances may become as effective as fixed appliances.

When considering clear aligner therapy or clear braces, educating patients about the advantages and disadvantages depends significantly on their expectations and compliance. Orthodontists should first communicate clearly with patients to rule out conventional braces if the patient desires no treatment responsibilities, is compliant in visiting the office monthly, and wishes to have all of the treatment performed by the dentist. Clear aligner therapy may not be suitable in this case.

However, if patients desire the benefits of clear aligner therapy, orthodontists must present the pros and cons to them. Patients must understand their compliance and responsibilities, including consistently wearing the aligners for 22-23 hours per day and only removing them to eat. One of the benefits of aligner systems is the opportunity to see the progression of tooth movement during the various stages of treatment. It is crucial to continuously motivate each patient during treatment to ensure their compliance and self-discipline to achieve the benefits of the treatment.

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