ISSN No:-2456-2165

Clear Aligners, A Milestone in Invisible Orthodontics – A Literature Review

Sharath Kumar Shetty[1], Haneesh Kiran P T[2], Mahesh Kumar Y[3],

[1.] Professor & HOD,
[2.] Post Graduate Student,
[3.] Professor,

Department of Orthodontics & Dentofacial Orthopaedics , K.V.G Dental College & Hospital , Sullia , Karnataka, India

Abstract:- The increase in awareness of optimal esthetics and the orthodontic treatment demand from adults has raised the demand for a more enhanced orthodontic treatment technique. Clear aligners are an alternative to conventional orthodontic braces and are manufactured to help guide teeth into their ideal position. Identical to braces, clear aligners use a gradual force for an organized tooth movement, but without metal wires or brackets. The aligners are made of a strong plastic material and are fabricated to fit each individual's mouth. Improved oral hygiene, discrete look, comfort and protection from tooth grinding are some of the major advantages of using the aligners. Clear aligner technology has been improving over the years and can correct many malocclusions that once would have been too complicated for this form of treatment. Continued developments on the technological front are being adapted to improve efficiency of clear aligners, especially in complex cases.

I. INTRODUCTION

With the recent surge in adults and adolescents looking forward to orthodontic treatment, there has been a marked increase in demand for appliances that are both more aesthetically pleasing and more comfortable than orthodox fixed appliances. As with fixed appliance modalities, the term Clear Aligner Therapy consists of a wide range of appliances with differing modes of action, methods of construction, and applicability to various malocclusion treatments. All share the use of clear thermoformed plastic aligners that cover many or all of the teeth, but from that common point, there are major and significant differences which affect the ability of any given system to treat a wide range of orthodontic problems. Clear Aligner Therapy was initially introduced to treat minor irregularities of tooth position only. Some aligner systems remain deliberately and explicitly limited to the correction of minor positional irregularities whilst others also claim to target complex malocclusions. Published clinical evidence supporting such claims is either lacking or, for the most part, well short of high-level scientific evidence. Nevertheless many Clear Aligner Therapy systems are marketed directly to the public, and some do not even require the intervention of any dental practitioner at any stage in the process.[1]

II. HISTORY

Kesling in 1940s first postulated the idea of using an aligner to align the teeth when he produced a tooth positioning appliance to redefine the finishing stages of orthodontic treatment. The appliance being a piece of pliable rubber prepared from a laboratory wax up of the teeth present in a Class I occlusion.This allowed for minimal tooth movements to be achieved while it maintained alignment of the remaining teeth present in the arch. Difficulty in tooth movement and only crown being tipped were few of its disadvantages. He foresaw that more rigorous and frank tooth movements could be accomplished with a series of aligners, while identifying the limitations of the technology present at the time. In the year 1971 an 'Invisible Retainer,' was intrtoduced by Ponitz which used Kesling's idea of pre-positioning teeth on a master study model.Identical to Kesling's appliance, the appliance could only produce minor tooth movements, again reaching its results by the tipping of crowns. Sheridan in the early 90s explained a method of using clear aligners in association with interproximal tooth reduction. The idea of accomplishing minor tooth movements with individual aligners had not changed. 'Kesling set-up' was necessary for each tooth movement, hence , a new impression was taken at almost every visit. The process asked for a increased amount of clinical and laboratory timings. In the year 1999 Align technology released Invisalign. This being the first orthodontic appliance to use the CAD- CAM technology. In placeof requirement of a new impression for every tooth movement, the technology allowed for multiple tooth set-ups to be obtained from a single impression. The arrival of this digital process uninvolved the inconvenience of previous aligner systems and made Kesling's concept authentic.Other aligner systems use like principles to attain their outcomes with all of these appliances evolving over time.[2]

III. CLINICAL AND RESERCH CONSEQUENCES

According to production methods, clear aligner systems can be broadly grouped into 2 different categories

1. Aligners made from thermoplastic materials through a manual set up
2. Systems using CAD-CAM technologies to design and produce aligners

➢ *Aligners Produced by Manual Set up*

The manual approach is a labour-intensive process, requiring manual repositioning of the teeth, wax setting, and production of vacuum-formed retainers. This approach allows the fabrication of aligners easily in laboratory conditions in a cost-effective manner. It also facilitates the follow-up process of the treatment and allows the orthodontist to make the necessary treatment changes at an earlier stage. Aligners are produced in various thickness levels (0.020-inch, 0.025-inch, or 0.030-inch). The use of gradually thickening aligners provides more control on tooth movement and reduces the pain caused by orthodontic forces. With one set of impressions, two or three aligners of various thickness levels are produced, and the patient is instructed to use each aligner for 10 to 15 days. The aligners are fabricated from a new working cast and obtained from a new impression taken at each visit, which allows the clinician to modify the treatment plan throughout the course of treatment, and to be able to follow the progression of tooth movement. Clear Aligner system CA (Scheu Dental, Germany) is an example of aligner systems requiring a manual setup.

➢ *Aligners Produced by CAD-CAM Technologies*

The incorporation of digital technology revolutionized the practice and appliances used in orthodontics. As in other fields of dentistry, CAD-CAM systems have become involved in orthodontics and aligner treatment. Invisalign being the best-known aligner system has become a generic name for other high-quality systems using CAD-CAM technology This system is known to be the most sophisticated and most commonly used clear aligner technology currently available. In 1999, the Invisalign system was introduced to the orthodontic market to treat mild malocclusions only, However, the development of different attachments and auxiliaries now enables Invisalign system to perform major tooth movements and treat more complex cases such as those requiring premolar extraction. Aligners in Invisalign system are designed and produced using CAD-CAM technology. The combination of computerized virtual treatment planning, and stereolithographic prototyping technology for manufacturing gives Invisalign a leading role in aligner therapy.

IV. BIOMECHANICS OF CLEAR ALIGNERS THERAPY

Understanding the mechanics of tooth movement using aligners could lead to the more appropriate selection of patients and more accurate treatment sequencing, leading to better results. Tooth movement mechanism with clear aligners can be explained from two different perspectives**.**

1.The displacement driven system

2.The force driven system.

The displacement driven system mainly controls simple movements such as tipping or minor rotations. Aligners are formed according to the position of the tooth in the next staged location and the tooth continues to move until it lines up with the aligner. This system is known to be less effective in controlling tooth movement and is insufficient in producing root movements.

The force driven system, however, requires bio-mechanical principles to facilitate tooth movement. Aligners are designed to apply desired forces on the tooth. The shape of aligners to produce such forces is not necessarily the same as the shape of the tooth. The movement required for each individual tooth, mechanical principles to accomplish this movement, and the aligner shape are determined via Clincheck (Align Technology, Santa Clara, CA, USA) software. The aligner shape is altered via pressure points or power ridges in order to apply the desired forces. Pressure points lead to more difficult uprighting and intrusion movements, whereas power ridges control axial root movements and torque. Despite the alterations in the shape of the aligner, movements such as root paralleling, extrusion, and rotation were still difficult to obtain using aligners until Align Tech. (Align Technology, Santa Clara, CA, USA) introduced smart force attachments for the Invisalign system. These attachments are small composite bulges designed to produce a force system favorable for the designed movement. Their position and shape are determined via Clincheck software according to the movement to be obtained. Extrusion attachment, rotation attachment, and root control attachments are currently used. Extrusion of a single tooth is moderately difficult using clear aligners when compared to fixed-appliance systems, however, some auxiliaries such as buttons and elastics can be used to facilitate this movement. Also, the extrusion of a group of teeth (i.e., maxillary incisors) can be performed using aligners.The use of temporary anchorage devices in combination with clear aligners further widened the range of treatments possible with aligners.

V. GENERATIONS OF CLEAR ALIGNERS

➢ *First-generation of clear aligners*

Earliest varities of these systems were just dependent on the aligner to achieve their results. Auxiliary elements were not combined. Not much research is available assessing the tooth movements achieved by these aligners. Djeu et al. compared their first 48 patients treated with Invisalign system with a cohort of fixed appliance patients.They assessed the consequences produced by the different treatment systems. In both groups, marginal ridge alignment and root angulation, Invisalign and fixed appliances had parallel results. But in terms of buccolingual inclination, occlusal contacts, occlusal relationship and overjet reduction, fixed appliances had pointedly better scores.[4]

➢ *Second-generation of clear aligners*

With the advent of technology, manufacturers initiated to encourage the use of attachments to advance tooth movement. Orthodontists could demand composite buttons to be positioned on the teeth and could also start to use inter-maxillary elastics. In two separate studies, Kravitz et al. assessed the correctness of tooth movements produced by these newer aligners. They compared the simulated tooth movements projected by tooth movement software with the clinical results achieved by aligners, aligners with attachments or aligners with interproximal reduction. In conclusion, the attachments that were presented in the second

ISSN No:-2456-2165

generation of aligners did not seem to advance overall accuracy. [4]

➢ *Third-generation of clear aligners*

With the aim to advance the outcomes and obtain better regulation of tooth movements with aligner appliances, efforts have been made to modify the methods in which aligners apply force. Attachments are now positioned automatically by the producer's software where extrusions, derotations and root movements are necessary. Indentations in the aligners are produced where root torque is necessary. Orthodontist can also look for non-precision attachments to be placed on the teeth where it is felt that they would advance the movements achieved. There are three common types of attachments: ellipsoid, bevelled and rectangular[4]

➢ *Considerations in treatment planning*

1. Biology of tooth movement should be paid attention to. Distalizing a tooth to a larger distances may not be possible dentally without the proper anchorage reinforcements such as a temporary anchorage devices.
2. Have orthodontic principles govern and dictate the movements. Distalizing an entire arch as a unit and seeing it displaced in the software is possible, however, again without extraoral forces, this is unlikely to happen.
3. When setting up the final overjet, consider not leaving a tight overjet, to accommodate the thickness of the aligner in determining the tooth position. Align default currently is to leave the overjet at 0.5mm to allow for the thickness of the aligner in the overjet position.
4. Optimized Attachments and aligner features are placed based on software algorithms to apply the optimal forces needed in the direction needed for the programmed tooth movement. One must neither consider replacing them nor removing them to experience their improved effectiveness on tooth movements.
5. If the treatment plan has Interproximal reduction, consider not removing tooth material unless there is the ability to procline or expand the teeth in the arch form and the periodontium is stable.
6. For Anteroposterior correction cases, anchorage control must be maintained with the use of elastics. Check for Precisions Cuts for Class II or Class III correction and leverage the tool in the software
7. Remember to take into consideration the treatment time needed to correct the Class II or Class III even when a virtual elastic simulation or Bite jump at the end of treatment is shown. The one stage jump is a simulation of the Anteroposterior correction and the expectation is that the Anteroposterior correction is occurring with the use of elastics or in some instances with surgery
8. Virtual simulations or bite jumps also occur in other dimensions such as vertical. We must remember these are virtual, and keep orthodontic principles in mind when correcting an openbite.
9. Precision Bite Ramps do not extend beyond 3mm and therefore will not be in occlusion with overjets more than 3mm. If larger biteramps would be needed, we must consider placing bite ramps on the canines and then switching to Precision Bite Ramps when the overjet is 3mm or less.
10. Leverage the occlusal contacts tool, to look for premature contacts as well as to finalize the occlusion. In some instances leaving heavy occlusal contacts may be desired such as in deepbite cases to overcorrect for posterior extrusion.
11. Overcorrection is prescribed by some clinicians to compensate for the lag of tooth movements accomplished in the aligners.

➢ *Tips for monitoring treatments*

1. Interproximal regions are defined through a mathematical algorithm and there are some assumptions of shape that are made that can lead to inaccuracies of treatment. Check contacts during treatment for binding with floss and if tight, loosen the tight contacts with a fine Interproximal reduction strip.
2. Check patients before delivering overcorrection aligners, especially virtual C-Chain. The intent of virtual C-Chain is to tighten contacts during a space closure case like elastic chain to close residual space in a traditional bracket and wire case. If the contacts are already closed or tight, overcorrection aligners are not needed. Adding overcorrection aligners with already tight contact can lead to residual overlap and/or residual crowding. Similar to leaving elastic chain for increased period of time and contacts overlap in brackets and wires.
3. Monitor tooth movements that are lagging behind or not tracking as they may be the one causing interferences. One common effect of posterior tooth tipping or lack of upper expansion may manifest as a posterior open bite.
4. Residual posterior open bite has many root causes, and identifying the root cause is critical to its solution. Look for anterior inferences due to anterior bite deepening or lack of deepbite correct, or retroclined incisors or undertorqued incisors. In some instances, as seen with some expansion cases, check to see that the upper lingual cusps are not causing the posterior openbite.
5. During treatment, there will be some tooth mobility especially with teeth with recession or reduced periodontal support. Like any orthodontic treatment, mobility is transitory

➢ *Indications For Clear Aligners*

1.In cases presenting with mild crowding and malalignment of teeth (1-5 mm) .
2.Cases with spacing (1-5 mm) .
3.Cases with increased overbite (Class II div 2 cases) .
4.Arches that are not wide enough and expansion can be achieved without exceeding tipping of the teeth
5.Absolute intrusion (1 or 2 teeth) .
6.Lower incisor extraction for severe crowding cases.
7.Cases that require molar tipping distally.(3)

➢ *Contraindications For Clear Aligners :*

1.Patients presenting with excessive spacing or crowding .
2.Marked anteroposterior discrepancies
3.Cases presenting with discrepancies between centric relation and centric occlusion
4.Teeth that are adversely rotated
5.Patients presenting with open bites
6.Tooth extrusion
7.Arches with multiple missing teeth. (4)

➢ *Advantages Of Clear Aligners :*

1.The trays are clear, aesthetic and comfortable. No metal brackets or wires are present which may to cause mouth irritation or lacerations.
2.Clear aligners are often not visible, allowing patients to smile with greater confidence
3.Better oral hygiene can be assured compared to that of fixed appliance.
4.Unlike traditional orthodontic brackets, the trays can be removed for brushing, flossing, and eating.
5.Good retention facilitated.
6.Decreased occlusal abrasion from parafunctional habits during treatment.
7.Disarticulation of the teeth may be advantageous for patients with TMJ problems.
8.Technically much easier than lingual appliances.
9.Approximating the treatment duration a little more precisely than braces .
10.Avoiding extractions of premolars by creating interdental space via interproximal reduction .
11.Healthier periodontal tissue and less risk of enamel decalcification by avoiding brackets
.

➢ *Disadvantages Of Clear Aligners :*

1.Since clear aligners are removable, they require more patient motivation to achieve the desired results.These devices must be worn 22 hours a day.
2.Clear aligners must be removed during meals, when drinking hot drinks that could spot or cause deformation, sugary drinks and during the oral hygiene.
3.Treatment time may exceed due to patient compliance to dentist's instructions, not wearing aligners the required number of hours per day, missed appointments, excessive bone growth, poor oral hygiene and broken appliances can lengthen treatment time, increase the cost, and thus can affect the quality of the end results.[6]

VI. CONCLUSIONS

There is a wide range of options from which a clinician can choose if clear aligner therapy is the desired treatment appliance. The differences between these appliances are profound which makes the choice of a specific appliance a critical decision determined by the severity of the malocclusion, the ability of the doctor to influence the final outcome, the speed and utility of the clinical treatment, and appliance aesthetics and comfort Treatment using clear aligners is becoming increasingly common in orthodontics. A better understanding of how tooth movement is achieved may lead to treatments that are more efficient. The role of uncontrolled tipping and loss of anchorage complicate the progression of programmed aligners. Further evaluation of patient characteristics, such as age, bone quality, and tooth morphometrics could aid in aligner treatment planning. The different aligner appliances have been progressive over time that has led to the usage of fixed pre-adjusted features to assist tooth control. Obtaining periodontal health is easier in patients treated with clear aligners and less white spot lesions develop during the treatment. Root resorption is still a risk associated with orthodontic treatment in aligner therapy, such as in fixed appliances. Long term stability studies are required in this field.

REFERENCES

[1]. Weir T. Clear aligners in orthodontic treatment. Australian dental journal. 2017 Mar;62:58-62.
[2]. Hennessy J, Al-Awadhi EA. Clear aligners generations and orthodontic tooth movement. Journal of orthodontics. 2016 Jan 2;43(1):68-76.
[3]. Tamer İ, Öztaş E, Marşan G. Orthodontic treatment with clear aligners and the scientific reality behind their marketing: a literature review. Turkish journal of orthodontics. 2019 Dec;32(4):241.
[4]. Hennessy J, Al-Awadhi EA. Clear aligners generations and orthodontic tooth movement. Journal of orthodontics. 2016 Jan 2;43(1):68-76.
[5]. Morton J, Derakhshan M, Kaza S, Li C. Design of the Invisalign system performance. InSeminars in orthodontics 2017 Mar 1 (Vol. 23, No. 1, pp. 3-11). WB Saunders.
[6]. Vijayaalakshmi LG, Sumathifelicita A. Clear aligners in orthodontics. International journal of management, IT & engineering. 2017 Jul;7(7).
[7]. Nelson G, Invisalign Summit 2005, Part I, Pacific Coast Society of Orthodontists Bulletin Winter 2005.
[8]. Robert L. Boyd, D.D.S., M.Ed , Esthetic Orthodontic Treatment Using the Invisalign Appliance for Moderate to Complex Malocclusions;J Dent Educ.2008; 72: 948-967
[9]. Miller RJ, Duong TT, Derackhshan M. Lower incisor extraction treatment with the Invisalign system. J Clin Orthod 2002; 36(2):95–102.9.
[10]. Womack WR, Ahn JH, Ammari Z, Castillo A. A new approach to correction of crowding. Am J Orthod Dentofacial Orthop 2002; 122(3):310–6.10.
[11]. Vlaskalic V, Boyd R. Orthodontic treatment of a mildly crowded malocclussion using Invisalign system. Aust Orthod J 2002; 17(1):41–6.14.
[12]. Boyd RL, Miller RJ, Vlaskalic V. The Invisalign system in adult orthodontics:mild crowding and space closure cases. J Clin Orthod 2000; 34(4):203–12.
[13]. Djeu G, Shelton S, Maganzini A. Outcome assessment of Invisalign and traditional orthodontic treatment compared with the American Board of Orthodontics objective grading system. Am J Orthod Dentofacial Orthop 2005; 128(3):292–8.13.
[14]. Boyd RL. Surgical-orthodontic treatment of two skeletal Class III patients with Invisalign and fixed appliances. J Clin Orthod 2005; 39(4):245–58.5.