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# Inhouse Aligners-A Review Article

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**Abstract:- An increasing number of people are looking for alternatives to fixed orthodontic appliances as the demand for cosmetic treatments rises. The past ten years have seen a rise in the use of aligners due to consumer preference and orthodontists' desire of reduced chair time. As the price for having all machinery needed to fabricate aligners has decreased, orthodontists may choose to fabricate aligners in-house. When aligners can be manufactured in-house, it will benefit patients as well as orthodontists. Thus, this article reviews the various aspects of the in-house aligners.**

*Keywords:- Aligners,3D Printing, Inhouse Fabrication, Workflow, Tooth Movements, Invivo Ageing*

## I. INTRODUCTION

Fixed appliances have been a part of orthodontic therapy for a long time. Nevertheless, the need for aesthetics during orthodontic treatment has prompted the creation of transparent aligners.[1] These aligners cover the buccal, lingual/palatal, and occlusal surfaces of the teeth and are composed of a thin, translucent plastic. Traditionally, they are replaced every two weeks and worn for at least 20 hours per day.[2]

Through the so-called "shape molding effect," which results from pre-existing mismatches between the aligner's shape and the dental tooth/arch geometry, aligners move teeth in orthodontic alignment. This force system is generated at the interface between the aligner and the tooth.[1]

The use of clear aligners has revolutionized orthodontics, challenging accepted wisdom regarding how orthodontists should move teeth.[3] The United States of America invented a computerized aligner system called Invisalign toward the end of the 1990s. Zia Chishti and Kelsey Wirth, two Stanford students, came up with the idea for the system. Clear aligners have changed dramatically since they were first put on the market in 1999.[4]

The cost and duration of the entire process is one of the main disadvantages of aligners. Shipping is another major concern during these pandemic times. Therefore, taking into account in-house aligner manufacture can only be advantageous to patients and orthodontists. Using an intraoral scanner and generic aligner programming tools, in-house aligners may be created by digitally cutting the models and simulating motions.[5]

CA has dramatically changed since the late 1990s with the introduction of computer-aided design (CAD) and computer-aided manufacturing (CAM) technology, as well as the Invisalign system by Align Technology, Inc.[6,7] Clinicians are now more inclined to produce their patients' aligners internally as orthodontic treatment planning software, three-dimensional (3D) scanners, and a variety of 3D verified printers and printing materials are readily available in dental offices.[8]

## II. HISTORY

The history of clear aligner therapy began in the twentieth century, when dental physicians began experimenting with using clear plastic aligners to straighten teeth.[9]

In the early 1940s, Kesling Introduced clear aligner. However, due to skepticism and a lack of advertising at the time, it did not become very popular. Clear aligners gained popularity as dental materials and 3D technology advanced.[10]

Sheridan established the use of interproximal tooth reduction (IPR) in conjunction with clear aligners in the early 1990s. Every tooth movement required a fresh setup. As a result, in order to produce a new aligner, a fresh imprint needed to be obtained at each visit, which added time to the procedure and increased laboratory effort.[11] In 1997, Zia Chishti and Kelsey Wirth founded the Align Company, which introduced the Invisalign aligner system (Align Technology, Santa Clara, California). They did this by combining the usage of plastic foils (Essix) with the idea of a tooth positioner. The Invisalign System, the first orthodontic appliance to combine computer-aided design (CAD) and computer-aided manufacturing (CAM), was launched in 1999 when align technology obtained FDA certification.[12]

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The early Invisalign system's utilization of computer technology to build the aligners was one of its primary benefits.[13] To generate a virtual model of the patient's bite, a digital scan or imprint of the patient's teeth was first utilized. The alignment of the aligners and the precise movements required to get the intended outcome were planned using this virtual model.[14] The early Invisalign system's use of "SmartTrack" material, which was created especially to offer the best force and control during tooth movement, was another crucial component.[9]

➢ *Advantages of Clear Aligners Over Conventional Braces*

Patients could eat, brush, and floss normally without needing to get around brackets and wires since the aligners were removable.[16] In addition to making the treatment procedure more pleasant and easy for the patients, this also lessened the chance of gum disease and tooth decay, which may be issues with traditional braces.[17] All things considered, the original Invisalign system was intended to be a more aesthetically attractive, practical, and pleasant substitute for conventional metal braces. It showed great promise and is still in widespread usage today.

## III. INHOUSE ALIGNERS

In-house aligner systems (IHAs), alternatively known as in-office aligners (IOA), in the strictest sense, refer to clear aligner systems wherein every aspect of the aligner fabrication from digital treatment planning (DTP) to the delivery of the orthodontic care is managed in the orthodontic office itself.

The cost and duration of the entire process is one of the main disadvantages of aligners. Taking these disadvantages into account, the orthodontist and the patient benefited from the in-house aligner manufacture.[5] Using an intraoral scanner and generic aligner programming tools, in-house aligners may be created by digitally cutting the models and simulating motions. Every model file can be ready for 3D printing when the aligner phases have been designed. Although the files may also be sent to a lab for printing, it has been demonstrated that internal manufacturing is more economical over an extended length of time.[13] After the models are produced, a thermoforming machine and a handpiece for cutting are needed. Materials are an essential component of domestic manufacturing, and research has shown that polyethylene terephthalate exhibits the least amount of deformation in a variety of circumstances.

➢ *Advantages of In-House Aligners*

- In comparison to purchasing aligners from companies, the cost of aligners produced by the physician is significantly lower.
- The orthodontist may monitor each step of treatment and modify the plan as necessary while using in-office aligners. By superimposing the data on earlier scans, therapy assessment is made possible by the flexibility to take intraoral scans as needed, as demonstrated in.
- Fusing a CBCT (converted to an STL format file) with the intraoral scan is a feature available in certain CAD software applications, such as Maestro Dental Studio. When repositioning the crowns during the setup process, this aids the orthodontist in seeing the tooth roots.
- There is almost no limit to the quantity of aligners that may be created in the office.
- When compared to aligners produced by a company outside of the clinic, the big advantage of in-house aligners is that the clinician quickly makes the aligning and staging which is in his mind instead of writing a recipe to the company technician, who is most of the time not even a dental technician.
- The self-sufficiency of in-house aligner production is even more advantageous in situations or clinical settings where access to external aligner companies is discontinued or limited (for example, during a pandemic lockdown).

➢ *Fabrication of Inhouse Aligners.*

Although 3D printing offers many practical benefits, the process of printing orthodontic appliances in-house, including its physical and mechanical properties, ageing pattern, chemical stability, and wider biological profile, is fraught with uncertainty due to technical aspects of the printing process and material properties.

In general, there are three types of aligner treatment:

- Complete aligner treatment.
- Hybrid aligner therapy, in which fixed appliances are used initially and aligners are used in the end (or vice versa).
- Aligner therapy in instances of recurrence.

The process for designing clear aligners is the same across all orthodontic software applications. Aligner resin can be used to build aligners for direct 3D digital printing with certain software programs. The process of creating aligners was explained using DeltaFace softwareTM; however, biomechanical factors were not covered in detail. With several options to assist the orthodontist in creating the study models required for aligner production or in designing the aligners for direct 3D printing, the program is user-friendly and effective.[15]

➢ *Workflow of Inhouse Aligners*

The complete workflow for the fabrication of IHAs essentially consists of the following steps:

- Intraoral scan;
- Digital treatment planning (DTP);
- Exporting serial aligner models;
- 3D printing;
- Thermoforming of aligners;
- Trimming of thermoformed aligners;
- Packing and labeling.

- The dental arches are first digitalized, often with the use of an intraoral scanner. In situations where polyvinyl siloxane imprints were taken, a desktop scanner may be employed. Plaster casts may be poured and scanned, or the impressions might be scanned straight.

You may use a filament or a resin substance to create a 3D model. Fused Deposition Modeling, or FDM, printers are used to make models while utilizing the filament. The filament model's primary benefit over the resin variant is its tenfold cost savings.[16] The filament model also has the significant benefit of being used right away upon printing.

- ✓ Curing and Labeling: The resin sculpture is assembled layer by layer by gentle curing of the resin. As a result, the resin model is not completely cured after printing. A final light curing is required. The models should be exposed to UV light for around 30 minutes in order to complete the curing process. The models are prepared for the aligner forming process following final curing. Before exporting the STL files from the program, each model needs to be labeled since several patient models at different stages of therapy could be printed simultaneously on the same table. Labeling is a simple process that involves using software to add bespoke text at a suitable location on the model to be engraved or embossed at a desired font size and depth.

- ✓ Plastic Foils for Aligner Fabrication: Several varieties of plastic foils are produced for the manufacture of aligners. These include variants of polyurethane, PET (polyethylene terephthalate), and PET-G. Businesses are concentrating on enhancing the plastic foils' elasticity, toughness, and resistance to color fading and microcracking in an oral environment and under force.

- If necessary, modify the occlusion in the second step. However, with intraoral scanning, the occlusion is characterized accurately the majority of the time.
- Creation of Model Bases and Border Cleaning: In this phase, the virtual dental models' borders should be either manually or automatically cleaned. Model bases are also produced, giving the dental model its final shape.[17]
- Tooth Numbering and Segmentation: The definition of the teeth that will be segmented by enabling them is the fourth phase in the process. Subsequently, the program prompts the user to specify the distal and mesial surfaces of every tooth. The program establishes the teeth's default angle and thereby isolates each tooth from its neighbor or neighbors.

Segmentation is the final step. The program computes and displays each tooth that will be moved during the setup phase in a variety of colors. It is imperative that each and every tooth be examined. If segmentation is done incorrectly, the operator can manually fix the issue.

- Defining Tooth Reference Axes: The operator modifies the teeth's center point in this stage. Every tooth's center point, often known as the "red point," serves as the benchmark for measuring all rotations and translations throughout the setup phase. The program itself makes calculations to determine the general location of each tooth's root in the space.

The dental arches' virtual setup is the next stage. Similar tools are included in all software applications of this kind, and the teeth can be changed independently using a tooth manipulator or by mathematically describing the change in angulation. IPR will be required when teeth are virtually shifted into a space-constrained region. When this is tried, the software determines the required space and shows it on the mesial and/or distal side of the tooth. The required quantity of IPR must be indicated in the software where it belongs. The division of the tooth motions into phases is one of the most crucial aspects of CAT design.[17]

The maxillary molars must shift in distinct stages if we want to distalize them and generate room. The initial phase of movement must include the molars. The crowded teeth must then be relocated into the space provided by the distalized molars in a second step. The "Add sequence" button in the present program can be used for this. It is necessary to carefully prepare and stage each and every tooth movement in order to accurately direct the software.[17]

It is possible to place attachments "in" (negative attachment) or "on" the teeth. The program also allows you to import attachments that were made by third parties.[1]

Additionally, attachments serve a crucial function in stabilizing the aligners during tooth movement through the appropriate utilization of these anchoring locations. An further key benefit of aligner therapy is the ability to employ every tooth as an anchor against the movement of one or two teeth. Sequential labeling of each virtual model to be produced is the final step. To ensure that the number is written on each aligner, it is helpful to write the number on the buccal surface of the final molar that will not be relocated. The operator can see how many aligners will be required for the therapy once this series of setup steps has been completed.

- ✓ Exporting Files: The orthodontist must now specify whether dental casts, which will be used to construct aligners, will be produced from or straight onto a 3D printer. If the latter is done, material can be saved by fabricating the printed functional models to be hollow and baseless.

- ✓ Dental Model Printing: Undigitization – It is now possible to print—that is, to transform the virtual dental models into a tangible thing by undigitizing them.

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The dental cast is cleaned with 91% isopropyl alcohol after printing, and postprinting curing is the next step. Working model printing is less common with FDM (FUSED DEPOSITION MODELLING) printers. They do, however, offer the benefit of being less expensive than resin printing techniques and not requiring additional post-printing steps.

Positioning Thermoforming Aligner thermoforming comes next after functioning model printing. Various thermoforming plastic foils are used in conjunction with vacuum or positive pressure thermoforming equipment in this method. The standard air pressure at sea level, which is between 0 and 1 bar, cannot be applied by vacuum thermoforming devices. On the other hand, the pressure that positive thermoforming pressure machines may apply is infinite. To precisely manufacture the aligners, a thermoforming machine that can generate the right pressure is essential.

Using the superimposition capability, the orthodontist may track at any point during the aligner treatment process and obtain a fresh intraoral scan to compare to the first one. Additionally, superimposition between the updated intraoral scan and the matching virtual dental cast is possible.

The orthodontist must complete a multi-step technique called "in-house aligner design and fabrication." The steps that are necessary for a good treatment outcome include intraoral scanning, clinical assessment, capturing radiographs and clinical photos, using CAD software, printing dental models in three dimensions, and thermoforming the aligners.[17]

## IV. ACCURACY OF TOOTH MOVEMENTS WITH ATTACHMENTS[11]

According to a study by Shivaporn Sachdev et al., for each of the six types of tooth movement, achieved tooth movements were considerably smaller than expected tooth movements. This result were complementary to the studies that found discrepancies between predicted and post treatment results. In a comparable manner, Krieger et al. discovered that planned tooth movement was superior than the actual result. Notably different rotational movements were accomplished and anticipated in another work by Charalampakis et al. The majority of clear aligner treatments did not fully establish the desired tooth movement as intended.

With anterior clear aligners, the overall accuracy of tooth movement was 56.18%. Mesiodistal movement was the most accurate tooth movement (72.33%), while intrusion movement was the least accurate (43.28%). Since clear aligners work by applying pressure to teeth, they must push against the attachment surfaces in order to extrude a tooth. The majority of research has focused on the poor extrusion efficiency of transparent aligners.

Based on a finite element evaluation, Gomez et al. proposed that tooth movement with only the aligner and no other modifications (e.g., attachments) has poor control on the inclination of teeth.[20]

➢ *Forces and Moments Generatred by 3D Printed Direct Aligners*

Two primary raw materials are used in the production of the numerous commercial products that are currently on the market: polyurethane-based polymeric material and polyethylene glycol terephthalate (PETG) polymeric material. Compared to PETG materials, the former has a better hardness and elasticity modulus but a lower creep resistance.

The limits of the material's ability to exert a constant force, even for the anticipated short intraoral service period, are set by the adverse effects of intraoral ageing on hardness, elastic modulus, and relaxation resistance, as demonstrated by the analysis of clinically aged Invisalign appliances from Align Technology, Santa Clara, California. Therefore, before using an unknown resin in 3D printed products, its composition, characteristics, structure, and the impact of intraoral ageing must all be fully characterised.

Changes in the mechanical characteristics of in-house 3D printed orthodontic aligners with intraoral ageing were examined in a 2021 study by Esad Can et al. Comparing the 3DPIN and Invisalign® appliances to traditional thermoformed aligners, they may offer more counter forces under the same tension. Compared to Invisalign® (40.0–40.8%) and traditional thermoformed aligners (34.0–35.9%) (20–22), the 3DPIN material's elastic index (29.4%), which measures the material's brittleness, was found to be significantly lower, suggesting a more ductile behaviour. However, compared to Invisalign®, the relaxation index was found to be significantly higher, indicating a higher decay of orthodontic pressures. Invisalign® and traditional thermoformed aligner materials had significantly lower indentation relaxation than 3DPIN material, indicating that the latter may be more prone to secondary reactions.

Even though intraoral service did not significantly alter the mechanical properties of 3DPIN aligners, there are still a number of issues that need to be looked into further before this method of aligner production is accepted as a substitute for traditional aligner treatment. These issues include printing conditions, printer type, and ways to ensure quality control of the printed material.

The stresses and moments produced are altered by targeted thickness increases in direct 3D-printed aligners, however they do so in intricate and unpredictable ways. It appears possible to maximise the recommended orthodontic movements while reducing undesired tooth movements by adjusting the labiolingual thicknesses of DPAs, which will increase the predictability of tooth movements.[21]

Furthermore, force and moment side effects on neighbouring teeth were lessened by increasing the lingual thickness of those teeth. Moment-to-force ratios suggestive of controlled tipping can be generated using DPAs.

According to a study (14) compared to 3DPIN aligners, conventional (thermoformed) aligners exhibit distinct deformation statuses (plastic versus elastic). Furthermore, an additional obstacle impacting the stability of the initial force magnitude during therapy is the stress relaxation phenomena brought on by ageing under intraoral circumstances. [12, 13] This mechanism has already been documented in aligners based on polyurethane or polyethylene terephthalate glycol (PETG) and could have clinical implications because of the quick reduction of force at the beginning of force initiation, which could lead to an inadequate application of forces. It becomes evident that, despite the fact that the 3DPIN aligner movement is mostly unproven and necessitates a detailed analysis of the final product, which may differ depending on the raw materials utilised, the printing/sintering process, and printer-output-related variables.

## V. CONCLUSION

Modern orthodontic treatment options like clear aligner therapy have become more and more popular recently because of its comfort, convenience, and almost invisible look. Using a series of clear plastic aligners that are custom-made, clear aligner therapy's biomechanics entails applying mild, controlled force on the teeth. There are many benefits to designing and printing aligners in-house. The rise of emerging companies that create aligner software, dental 3D printers, intraoral scanners, novel thermoforming materials, and, most recently, resin for direct aligner printing, indicates a trend towards in-house aligner design and manufacturing. In the discipline of orthodontics, including in-house aligner manufacture by orthodontists has the potential to be revolutionary.

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