

## AN ERA OF NEW INVISIBLE INNINGS IN ORTHODONTICS

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### Abstract

**Aims and Objectives:** The objective of this review is to search the literature on repositioners and present as to how it has emerged as a crucial treatment plan in modern orthodontics. The conventional orthodontic treatments were deemed tiresome since a lot of impressions had to be taken which demanded more clinical hours and efforts in the laboratories to manufacture appliances. Apart from this, aesthetics, and patient discomfort such as pain, longer duration of treatment, continuous wire adjustments, restrictive dietary habits, poor oral hygiene, patient compliance, were other areas of concern since a long time now. Clear aligners, which is a concatenation of removable thermoplastic polyurethane aligners, came into limelight as an aesthetic, comfortable, alternative to the traditional orthodontic treatments. This system makes use of CAD/CAM technology which plays a pivotal role in the success of clear aligners. This literature review aims to discuss about the advancements in the clear aligner system over the years and how it has proved to be an indispensable asset in Dentistry. However, certain limitations still need to be addressed to improve the efficiency of this system.

**Keywords:** Clear Aligners, 3-D Printing, Interproximal tooth reduction

**Introduction:** Orthodontics, the oldest branch of dentistry, deals with the proper alignment of teeth within the dental arch. The conventional orthodontic treatments were deemed tiresome since a lot more impressions had to be taken which demanded more clinical hours and efforts required in the laboratories to manufacture appliances. Apart from this, aesthetics, and patient discomfort such as pain, longer duration of treatment, restrictive dietary habits, poor oral hygiene, patient compliance, were other areas of concern since a long time now.

In 1998<sup>1</sup>, a breakthrough was achieved when Invisalign was launched by Align technology (Santa Clara, Calif, USA). Clear aligners, a concatenation of removable thermoplastic polyurethane aligners came into limelight as an aesthetic, comfortable, substitute to the traditional orthodontic treatments. Also, for the aligner treatments to be reasonable and effectual, the desired and actual outcomes had to be comparable. For this purpose<sup>2</sup>, clear aligners use CAD/CAM technology for the fabrication of customized aligners which help to reflect the treatment outcome and minimizes chances of manual errors. The landmark study<sup>3</sup> by Kravitz et al was based on evaluation of accuracy in anterior tooth movements with clear aligners. Recent<sup>4</sup> studies have also demonstrated the successful correction of mild to moderate anterior open bite using clear aligners, mainly via extrusion of incisors. Studies<sup>5</sup> also suggest that this appliance helps in the correction of deep bite through proclination of mandibular incisors. It<sup>6</sup> has been clinically proven to be effective in cases of minor space closure, lingual constriction, and marginal ridge height discrepancies. Significant improvement was also seen in Class 2, division 1 malocclusion. There has been a marked difference<sup>7</sup> between the earlier studies of clear aligners and the most recently conducted ones, with respect to the treatment modalities. Previously, there have been notable limitations in treating complex malocclusions with clear aligners whereas some of the latest studies have shown its efficiency in the correction of moderate to difficult malocclusions in the field of Orthodontics. This difference is mainly attributed to the fact that in the past the evaluation was done after four years of appliance development which has been recently increased to ten years of subjective use.

This review article throws light on some of the malocclusions that can be successfully corrected with clear aligner therapy, having a more aesthetic

approach. It also deals with how the clear aligner therapy has improved over the years in bringing a significant change in the field of modern Orthodontics.

**History:** Clear Essix Aligners, for reduction of teeth interproximally and its alignment was first described in 1995 by Sheridan and Sheridan et al<sup>8</sup> and their method has been successfully implemented over the years. But the disadvantage of this method was that for each tooth movement, irrespective of the number of teeth involved, an original replica of the set up along with a fresh series of impressions was required at almost each of the appointments, making it tiresome for both the patient and the Orthodontist.

In 1971, Ponitz<sup>9</sup> recommended an analogous appliance called the “invisible retainer”, which he claimed to produce limited tooth movement.

India is estimated to have approximately half a million new orthodontic cases each year, out of which a higher percentage of these cases are included in the category of complex malocclusions. Thus, to treat such complex cases in a more aesthetic way, clear aligners were first launched in India by Align Technology on 5<sup>th</sup> February 2016, with its headquarters in Mumbai.

CAD/CAM in Dentistry was first introduced by Dr Duret in 1971, when he used this technology to fabricate a crown. Over the years this technology has become an important aid in the arena of Modern Dentistry, be it Prosthodontics, Orthodontics, or Implants. It plays a pivotal role in the success of clear aligners and fixed Orthodontics in general.

Another innovation which has highly contributed to the success of clear aligners is the technology of 3D printing. Chuck Hall<sup>10</sup> was the first one to develop this idea when he was working on “*Apparatus for production of three-dimensional objects by stereolithography*” on August 8, 1984. Another form of three-dimensional printing was introduced in 1998 by Polyjet Photopolymer printing. The first use of this technology in Dentistry was during the late 1990`s for making dental implants. Currently, commercially available forms for use are- SLA, DLP, FDM, PPP. Combining 3D printing with intraoral scanners makes it possible to retrieve the models for use, without the need for physical storage. Retainers can be successfully printed using the mechanics of stereolithography.

The concept that revolutionizes clear aligner therapy<sup>11</sup>, is the scanning and imaging of particularly accurate casts, derived out of highly precise impressions. In this the dentist has the advantage of visualising the digital models till completion of the treatment, using a software program called “ClinCheck”<sup>12</sup>. Changes can be made through this software system till the desired result is accomplished. Only then are the original aligners fabricated and dispatched.

**Various Researches Conducted:** The following studies and research work have been compiled from the different standard journals available in Orthodontics:

A comparative study<sup>13</sup> done among patients treated using clear aligners and the ones treated with traditional fixed appliances revealed that the total alignment change was greater in the repositioner cluster as compared to the group with braces, mostly in the alignment of the maxillary anterior dentition. A higher relapse rate was, however, seen in CAT patients as compared to the ones who had opted for the standard fixed appliances.

Clear aligners<sup>14</sup> can achieve predicted treatment outcomes with high precision in non-extraction cases, although there might be some variations between the actual outcomes and the predicted outcomes in a few cases. Maxillary lateral incisors, canines and first premolars showed the least predictable variations according to the statistical data.

Studies show that patients with less complex malocclusions<sup>15</sup> require a treatment period of approximately five months longer with clear aligners as compared to conventional braces, but the treatment and the six month follow up occlusal results are identical for both.

Research<sup>16</sup> has shown aligners to be ineffective in intrusion or extrusion of posterior teeth. Also, derotation is one of the most cumbersome movements to be achieved with clear aligners, particularly in cases of cylindrical teeth like canines and premolars (lowest accuracy rate). The mean accuracy<sup>17</sup> for all tooth movements was fifty percent with the highest level of precision seen with a buccal-lingual crown tip (56%). Mild to moderate anterior open bites<sup>18</sup> have

been corrected mainly via incisor extrusion. Improvement was also noticed in cases of deep overbites, primarily by proclination of the mandibular incisors.

No enhancements were seen in antero-posterior correction<sup>19</sup> in Class 2 malocclusion patients when attempts were made to correct it with class 2 elastics. The extent of deep bite correction achieved was 28.8% and 38.9% of the desired extents in patients with Class 1 and Class 2 malocclusions, respectively.

No statistical<sup>20</sup> difference was seen in precision among the maxillary and mandibular dentition of a similar category for any teeth movements studied.

A study conducted by M.G. Taylor<sup>21</sup> showed how the orthodontic tooth movement affected the periodontal soft tissues using clear aligners. It was performed on a hundred subjects and the reaction on the tissues was evaluated using papillary bleeding score and periodontal pocket depth. The conclusion of the study was that the periodontal pocket depth improved with use of clear aligners during orthodontic treatment as compared to the conventional fixed appliances.

In clear aligner therapy<sup>22</sup>, patients upgrade to a new set of aligners in approximately a fortnight, thus giving less trauma and pain than the fixed appliances. Moreover, fixed appliances must be modified in every forty-two days, exert more force, which leads to shortening of the roots of teeth in most patients.

Digital treatment planning<sup>23</sup> is necessary as part of the clear aligner therapy protocol to allow the patients to assess the projected smile design, know the duration of the treatment, analyse a plethora of plans and make a more calculated choice as to whether or not to use aligners.

Patient compliance<sup>24</sup> is better with CAT since it can be easily removed by the patient while eating, drinking, getting it checked by the orthodontist or for maintaining oral hygiene. This also helps in preventing the demineralisation of teeth which is a common occurrence in patients with fixed appliance treatment.

Schupp et al<sup>25</sup> treated two anterior open bite cases favourably with clear aligners alone. Proper overjet and overbite were achieved in 17- 20 months

after treatment. Canine guidance and proper alignment of the anterior teeth was seen on both the sides, which closely resembled the projections of ClinCheck along with good post-treatment stability.

Recent<sup>26</sup> advances include attachment design to enhance control of tooth movements three dimensionally. These are crucial in extraction cases as they provide mechanical retention to permit multiple intrusions.

Clear Aligners have a key role to play in each of the services offered by the Orthodontic Speciality, namely;

**Preventive Orthodontics:** A correlation<sup>27</sup> was drawn between the efficacy of bodily expansion and the desired extent of expansion of the arch. It was concluded that though the width of the arch could be modified using clear aligners, the expansion was due to the tipping movement. The decreased efficacy of bodily buccal expansion by Invisalign made the analysis of initial position and presence of adequate root-buccal torque of the posterior teeth a necessity.

**Interceptive Orthodontics:** A study conducted to correlate the patients' experiences with Invisalign Teen and Mandibular Advancement<sup>28</sup> (ITMA), and Twin Block (TB) appliances showed that insertion of the appliance was more cumbersome for TB patients (21.8% vs 4.44% for ITMA) , also they required additional number of appointments as the appliance had a higher wreckage rate (50% VS 22.2% FOR ITMA) . There have been quite a few occurrences of soreness in the teeth, cheek, and lip region in the ITMA group. The feeling of being embarrassed persisted in TB patients over a long period of time (14.3% vs 0% for ITMA) . Speech, soreness of the lips and cheeks, drooling worsened initially for both the groups, but improvement was seen over a period of time. Though no variations were seen in the groups concerning visible changes of the face, satisfactory treatment experience or time to get habituated to the appliance, significant differences were observed regarding appliance wear and its management, role as well as the level of comfort experienced.

The interceptive treatment<sup>29</sup> with clear aligners is effective in the mixed dentition period, proven of producing clinical results, although not always with the first set of aligners. The success in correcting various malocclusions

depends upon the complexity of the malocclusion, with more complex malocclusions having a lower efficiency rate.

A study by Li et al<sup>30</sup> established that good results can be achieved in extraction cases using clear aligners with proper angulation of roots.

In cases of crowding, where extraction of teeth is not an option, the role of interproximal reduction (IPR) is very important to gain space and decrease the risks associated from the periodontal point of view which also contributes to relieving issues such as dental caries, increased loss of alveolar crest and other complications associated with the gingiva. In cases of clear aligner therapy, IPR has to be planned during the software set up where the selection of spaces and the amount of enamel to be reduced is at the discretion of the orthodontist. A critical aspect to ensure the accuracy of the results is that the amount of IPR planned must be in accordance with the amount of IPR achieved.

**Corrective Orthodontics:** Ravera et al<sup>31</sup> performed a study which demonstrated how the bodily movement of maxillary molars can be achieved using clear aligners when combined along with class 2 elastics.

But the highest rate of accuracy was seen with molar distalization (87%), eliminating usage of class 2 elastics.

With clear aligners, the most accepted treatment protocol to achieve intrusion within a limited time period, is by applying ideal intrusion force on the chosen teeth while keeping the anchorage teeth stable. Thus, it can be optimally used in the treatment of cases with mild to moderate anterior open bite, barring the complex cases.

Rotational movements of more than fifteen degrees greatly diminished the accuracy in movement of the maxillary canines. Studies<sup>32</sup> also suggest that this appliance helps in the correction of deep bite through proclination of mandibular incisors. It<sup>33</sup> has been clinically proven to be effective in cases of minor space closure, lingual constriction, and marginal ridge height discrepancies. No significant corrections<sup>34</sup> were seen in patients with Class 2 malocclusion, using elastics for a period of seven months, although appreciable improvements were seen with respect to the combined ABO points, teeth alignment and interproximal contacts, even in patients with Class 1 malocclusion.

A case study was done in which the patient presented with Class 1 malocclusion, revealing a midline diastema, excessive overjet and crowding in the maxillary and mandibular anterior teeth region. The treatment protocol comprised of extraction of the maxillary and mandibular first premolars bilaterally including correction of severe crowding using clear aligners, elastics, and fixed appliances, which proved to be quite effective.

With Invisalign, it is possible to chalk out consecutive distalizations of the maxillary and mandibular dentition for correction of Angle's Class 2 or 3 malocclusion part by part.

The Invisalign System in association with tooth extraction was able to achieve the desired overjet and overbite and correct the crossbite, to establish a Class 1 canine relationship without much interference with respect to the patients' aesthetic profile. Apart from this, the procedure was minimally invasive, increasing patient compliance.

For correction of Class 3 malocclusion, Invisalign was used in conjunction with class 3 interarch elastics which led to the achievement of stable results. It can be a reasonable alternative to the traditional fixed appliances in the early intervention of Class 3 malocclusion.

**Surgical Orthodontics:** Alveolar corticotomy surgery<sup>35</sup> is able to fasten orthodontic tooth movement, but continuous follow ups are pivotal, keeping in mind the rapid momentum of aligner change. A useful aid clinically, can be the subjective monitoring of "corticotomy accelerated aligner-mediated orthodontic tooth movement" to quickly detect and correct any errors in movement.

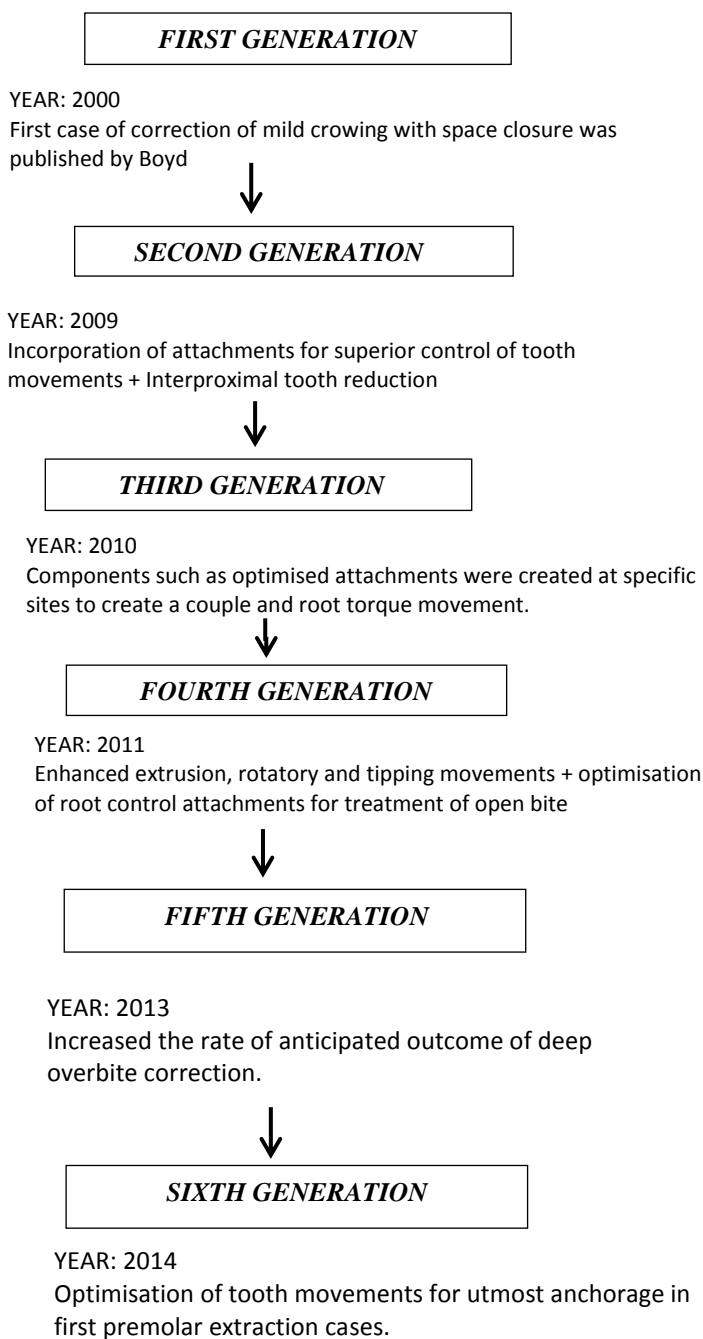
Clear aligners, in association with orthognathic surgery for critical dentofacial complications is rarely used, although, in a study conducted<sup>36</sup>, it was established that intricate surgeries involving the Orthognathic region can be successfully conducted in patients, but more trials are yet to be conducted regarding the efficacy of clear aligners in such procedures.

Clear aligner therapy in association with mandibular advancement, has been proven to be clinically effective in correcting Class 2 molar relationship during the pubertal growth phase of the patient. It also produces less proclination of the mandibular incisors in comparison to traditional appliances.



**Material and Methods:** As said by Mark Benioff, “The only constant in the technology industry is change.” Similarly, over the years, clear aligner therapy has gone through a number of modifications to fulfil its purpose of treating the various malocclusions in a more effective, aesthetic way, thus, improving patient compliance.

For this purpose, till date, eight generations of clear aligners have been introduced;





**SEVENTH GENERATION**

YEAR: 2016

Enhancement of root force for better movement of maxillary lateral incisors + to avoid posterior open bites.



**EIGHTH GENERATION**

YEAR: 2020

The first step in product Enhances the probability of deep bite correction + reduces the probability of buccal crown tipping during posterior arch expansion which include cephalometric analysis, images, and study models of the patient.

Commercial clear aligner manufacturing no longer uses the pioneering manual methods; instead, it now uses a digital fabrication process that makes use of the CAD/CAM software and a virtual program code.

A programmed replica of the patient's teeth serves as a foundation for digital designing of the desired tooth movements using aligners and can be acquired either directly (using photographs) or indirectly (using polyvinyl siloxane (PVS) putty impressions) which are then scanned using intraoral techniques.

Then, using CAD platforms, digital treatment planning along with alterations in biomechanics of the dentition are carried out.

The digital three dimensional set up are discretely segmented by computer algorithms. It is now feasible to import and overlay computed tomography (CT) scan data to further visualise the tooth roots.

The positioning of the teeth is altered through incremental motions towards the final positions sought, leading to the creation of individual digital set ups with teeth in the predetermined spots in every segment.

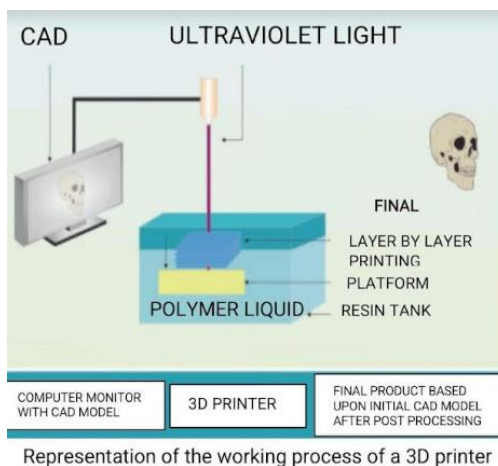
Each of these virtual setup models is printed in three dimensions using additive or subtractive manufacturing methods (milling or 3D printing), respectively, using CAM technology.

Currently, the most often utilised technology for creating orthodontic models is three-dimensional printing. This technique<sup>37</sup> comes with the advantage of same day appliance delivery, which makes aligners more cost-

effective in comparison to its conventional counterpart. Also, one week of intraoral use does not significantly alter the mechanical properties of an in-house 3D-printed clear aligner, thus, making it an indispensable treatment option in today`s world of modern dentistry.

After that, the physical copies are thermoformed with the corresponding sequence of clear aligners, and the copies are trimmed and polished. Depending on types of malocclusions, the protocol for updating the aligners, and the amount of adjustments, these procedures take up a lot of time, are exhaustive, and quite expensive.

Research is needed to determine the environmental impact of producing clear aligners because of worries about the burden of plastic on the environment.



**Conclusion:** There has been a great deal of change in the clear aligner therapy over the years, which can be attributed to the recent advances in the field of technology. This system provides an ideal amalgamation of aesthetics, comfort, good oral hygiene which in turn improves patient compliance. Studies have also shown the efficacy of aligner therapy in treating various orthodontic complexities, though, in comparison with fixed appliances, certain disadvantages are still prevalent. Thus, additional research is required to further improve the properties of clear aligners so that they emerge as a pioneer treatment system in the field of Orthodontics.

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