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Review Article

Rise & review of invisalign clear aligner system

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ABSTRACT

This review article will discuss Invisalign (Align Technology, Santa Clara, Calif) product in depth. How this system has evolved since it has been launched, how it differs from other clear aligners, why the results with Invisalign are more predictable than other clear aligner therapy and how Invisalign has managed to achieve these results. Advantages, disadvantages and its limitations. Aligners in COVID-19 pandemic. As clear aligner therapy is gaining more and more popularity among adult patients this article might be useful for orthodontist who are planning to incorporate Invisalign and clear aligners in their practice.

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1. Introduction & History

The brainchild of Invisalign is Zia Chishti who was undergoing orthodontic treatment and was provided with series of thermoplastic retainers; who then partnered with Kelsey Wirth to develop Align Technology in 1997. FDA approval came through in 1998 and sales began in 1999.

Since inception they have been constantly evolving with the latest update being G8 attachments in 2020. This article will in depth discuss the generations of Invisalign and features introduced with every new generation for achieving more predictable results with complex and multi planer tooth movements required in comprehensive orthodontics.

Till date over 10 million patients have been treated with Invisalign.¹

Initially limited only too orthodontist now Invisalign is available for experienced practioners too.

This review article will further discuss the evolution of Invisalign and how it differs from of clear aligners.

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1.1. Evolution

1st generation of aligners were displacement-driven i.e solely dependent upon aligners shape for results and no attachments were involved. Boyd was first to publish a case report of a mild crowding and space closure case by Invisalign in 2000.² Till September 2001, Invisalign® (Align Technology, San Jose, CA, USA) used a polymer mixture named Proceed30 (PC30) to fabricate aligners.³

2nd generation - In 2009 Invisalign introduced Smart Force attachments like, for extrusions and rotations which are patient specific and tooth specific and which continuously deliver forces to teeth, Power Ridges(TM) which were exclusively available for Invisalign Teen are now available in all products where specific tooth movements are required like lingual root torque, and Velocity Optimization is now integrated in the case set up and doctors no longer need to identify the velocity for specific tooth movements, finally Interproximal Reduction can now be planned at later stages in cases where contact points are difficult to access before alignment is complete.⁴ Later, a single layered polymer material Exceed30 (EX30) was used which was 1.5 times more elastic than PC 30. This

EX30 material helped with easy insertion and removal of aligner trays and better adaption was achieved.³

3rd generation - In year 2010 G3 attachments were introduced for optimized rotation control of premolars (earlier available only for canines), Power Ridge for lower anteriors (earlier available only upper anteriors) and lingual power ridge for upper anteriors. Also, to improve the outcome in Class II and Class III malocclusions new Precision Cuts (doctor prescribed pre-cuts) were introduced which would help in easy attachment of Class II & Class III interarch elastics, (earlier doctors had to manually cut the aligners).⁵

4th generation - In year 2011 G4 attachments were introduced to enhance the clinical outcomes in Open Bites cases with inclusion of multiple teeth and improved Optimized Extrusion Attachments in cases of anterior open bite. Predictability of upper lateral incisors tooth movement was improved with help of New Multi plane movements feature were introduced to improve control of upper laterals undergoing extrusion along with rotation and/or crown tipping. Optimized Root Control attachment for better mesio distal root control of canines and central incisors.⁶

5th generation - Since 2013, multilayer aromatic material made of a copolyester and thermoplastic polyurethane Smart Track (LD30) is been used.³ Highlights of this material are greater and constant force delivery, chemical stability and precise fit. G5 attachments for correction of deep bite were introduced to level the curve of spee by controlled premolar extrusion and anterior intrusion. Also Precision bite ramps for disocclusion of posterior teeth undergoing correction of deep bite were introduced in same year.⁷

6th generation - Year 2014 Invisalign G6 for first premolar extraction: Optimized retraction attachments were introduced for bodily movement of canine which would eliminate unwanted tipping and anterior extrusion with or without elastics. Also Optimized Anchorage Attachments were introduced to strengthen posterior anchorage.⁸

7th generation Invisalign aims to deliver better finishing outcomes of case which were faced by some clinicians, G7 delivers better upper lateral control, improved root control, and features to address prevention of posterior open bites.⁹

8th generation G8 attachments for crowding and crossbite cases: Optimized expansion support and rotation attachments to reduce the potential for buccal crown tipping during posterior arch expansion and SmartForce aligner activation for anterior intrusion with improvements in the treatment plan set-ups to level the Curve of Spee and demonstrates up to 2x improvement in predictability of incisor intrusion for deep bite cases.¹⁰

With 2021 update, a New Invisalign Professional Whitening System which revolutionizes teeth whitening with an all-in-one solution that enables Invisalign trained doctors to straighten and whiten teeth at the same time has

been introduced.¹¹

1.2. ClinCheck digital treatment workflow

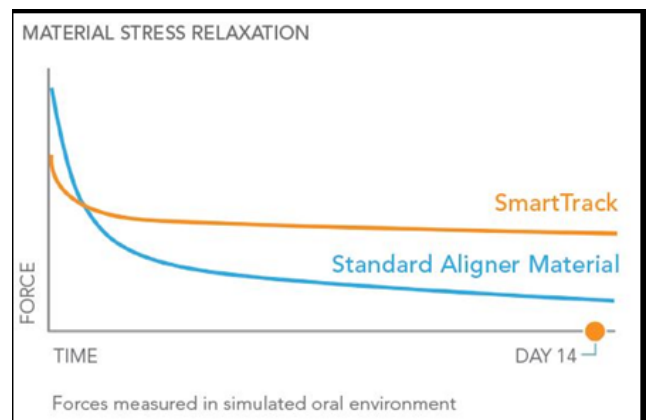
The First Step in this process is Patient selection & evaluation. Online evaluation tool helps you to evaluate the complexity of case, whether it is Simple with predictable treatment approach or Intermediate with variable treatment approach or Complex with less predictable approach. Certain guidelines depending upon patients condition have been developed to categorize the case like surgical, extraction, distalization, expansion etc. Next step is intra oral scans, patients bite is evaluated and complete set of records are updated. Next step is Treatment Prescription & ClinCheck plan approval where staging Selection of Optimized attachments, Precision cuts is done. Once finalized Clincheck plan is reviewed and approved and aligners move to fabrication stage. Once the aligners have been received they are checked for their fit the plan is reviewed once and treatment begins with placement of attachments or IPR if required any. Treatment Monitoring is done. Before finishing the case advance monitoring is performed and if required a new scan can be planned and refinement set of aligners can be ordered. Once all the finishing criteria's are met, retention is planned and viverra retainers are delivered.

1.3. How does Invisalign differ from clear aligners?

Invisalign acts as a Force driven System as compared to standard aligners which are displacement driven.

1.3.1. Smart track (Align Technology) material

With proprietary Smart Track material aligner is able to apply gentle, constant forces during the course of treatment, improving control over individual tooth movements, and eliciting a predictable biological response from the periodontal tissues and supporting structures.¹²

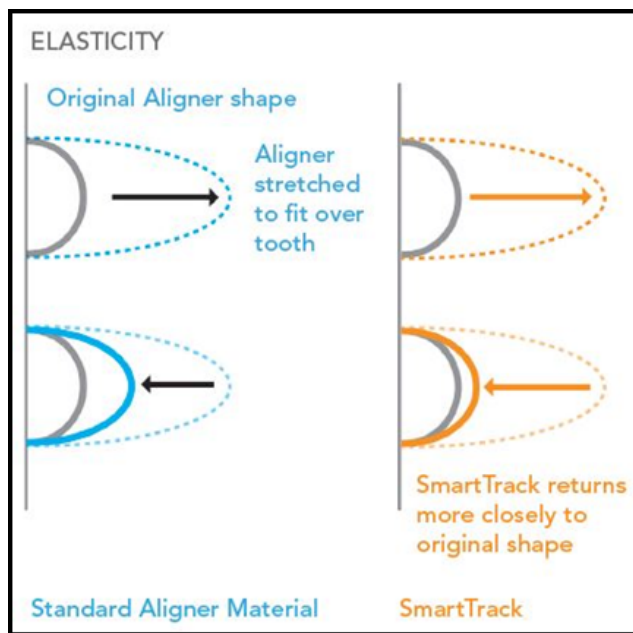


With Standard Clear Aligner material forces degrade quickly in initial days of aligner wear whereas with

Table 1: Highlights of evolution of Invisalign

| Year | Updates |
|------|---|
| 1999 | Sales began |
| 2000 | first case report by Boyd |
| 2008 | Align institute |
| 2009 | Smart Force attachments |
| 2010 | G3 Precision Cuts for Class II/III inter maxillary elastics |
| 2011 | G4 Optimized Extrusion Attachments for anterior teeth during treatment of open bites |
| 2012 | Smart Track aligner material |
| 2013 | G5 deep bite correction, precision bite ramps |
| 2014 | G6 Premolar extraction cases Optimized Retraction Attachments for bodily movement during canine retraction Optimized Anchorage Attachments |
| 2016 | G7 Molar retention attachments prevention of posterior open bites |
| 2020 | G8- Crowding crossbite, pGosterior expansion and deep bite cases |
| 2020 | Clincheck™ PRO 6.0 and clincheck "in-face" visualization for invisalign treatment |
| 2021 | Professional whitening system optimized for invisalign aligners and vivera retainers |

SmartTrack more constant forces are applied over a period of 14 days.



The new SmartTrack material has high elastic properties which enables it to return more closely to original shape, and also allowing it to precisely fit to tooth, attachments and interproximal areas. Its flexibility makes it easy to wear and remove the aligner which indirectly increases patient comfort.¹³

To conclude Smart Track material

1. Applies continuous and gentle forces
2. Helps in precise fit
3. Reduces pain
4. Highly elastic and has high shape memory
5. Improves tracking of tooth movement

1.3.2. Smart force features (involving attachments and activations)

These are features (attachments) designed to direct and deliver appropriate biomechanical forces on tooth which in turn enhance the predictability of orthodontic tooth movement.¹²

With Conventional aligners the bevelled attachments are helpful in achieving limited orthodontic correction like aligning the dentition, whereas with SmartForce more complex movements can be achieved which are required in comprehensive orthodontics since the introduction of G3 attachments.¹⁴

Such complex force systems like optimized attachments, pressure areas, pressure points power ridges appear in Clincheck Software and are automatically placed by TREAT software while staging the treatment with the prescription provided by doctor. Such automated and customized force systems allows increasing the predictability of complex tooth movements like root torque, bodily movements and correction of deep bites, etc.¹²

With SmartForce Aligner Activations, select areas of the aligner surface are specifically contoured to apply optimal forces to the tooth surfaces to control the location, direction, and intensity of the force to produce the desired outcome and minimize unwanted or unintended movements.¹²

2. Smart Stage technology

SmartStage technology is used to provide an ideal progression of tooth movement to improve the predictability of proposed movements while reducing unwanted interferences during treatment which may result from unwanted tooth movement. SmartStage technology implements algorithms that determine how the teeth will be staged to move, which teeth move, and when.¹²

For example, in premolar extraction case canines are first retracted to 1/3 extraction space and then anteriors are retracted to preserve and enhance the posterior anchorage.

With such two-step retraction common side effects like steeping of curve of spee are avoided and better control over bodily movements are achieved.



Fig. 1: Sample photo of clear aligner



Fig. 2: Sample photo of smart track invisalign aligner

2.1. Advantages

The first major and obvious advantage that clear aligners offer is that they are invisible.

With Invisalign faster and predictable results can be achieved as all movements are digitally planned.

Common and major disadvantage with fixed orthodontic mechanotherapy is diet restrictions. With Invisalign there are no as such diet restrictions like avoiding soft, sticky and crunchy foodstuffs as you have to remove the aligner while having food.

Aligners allow to maintain good oral hygiene with less gingival and periodontal problems.¹⁵

With aligners a minor relapse can be treated easily with help of your last set of tray.

Aligners are helpful in correction of certain kind of tooth movements like deep bite where intrusion more

predictability with intrusion mechanics and disocclusion of teeth, and mild anterior open bite cases.

They are also helpful in eliminating the myofascial pain associated with parafunctional habits by disoccluding teeth.

Decreased pain levels and mucosal irritation as compared with fixed orthodontic appliances

Aligners are advisable for patients with minor enamel defects in whom bonding procedures are difficult, those patients who require minor restorative procedures and who require bleaching.

Patients with short roots are also good candidates for aligners with lesser chances of root resorption.¹⁶

2.2. Disadvantages

One and major disadvantage with all clear aligner cases is patient compliance. A 20-22 hours wear is must for majority of cases, hence self-motivation is utmost requirement for all aligner cases

Aligners are not able to finish the cases as well as with fixed orthodontic mechanotherapy, as extrusion teeth with aligners is difficult.¹⁵

Complex cases like extraction should be treated with caution.

2.3. Indications¹⁷

Aligners are indicated in mild malalignment (1 to 5 mm of crowding or spacing) cases as more severe cases require excessive IPR or buccal expansion which is difficult to achieve.

In cases of deep overbite as intrusive movements are more predictable non-skeletally constricted arches that can be expanded with limited tipping of the teeth mild relapse after previous fixed-appliance treatment.

2.4. Limitations¹⁷

Certain cases which are difficult to treat with aligners are as follows.

Cases where crowding and spacing is greater than 5 mm Skeletal anterior-posterior discrepancies of more than 2 mm as measured in cuspid relationships centric relation and centric occlusion discrepancies severely rotated teeth greater than 20 degrees extrusion of teeth severely tipped teeth more than 45 degrees teeth with short clinical crowns arches with multiple missing teeth.

3. Aligners in COVID-19

There are certain advantages of aligners over conventional fixed orthodontic mechanotherapy as these are digitally planned.

Contact with patient's saliva can be reduced with help of digital scans, rather than making impressions and increasing chair time.

Entire treatment planning process is digitalized with TREAT & ClinCheck Software, again reducing chairside time.

Instructions, maintenance and follow ups can be done on phone calls, video calls or can be communicated digitally.

4. Conclusion

Invisalign and Clear aligner therapy has evolved drastically since its invention though the foundation was based on the ideas of Kesling, Nahoum, Sheridan and others.¹⁸ The recent digital era has helped for its evolution, greater acceptance and mass production. The Invisalign system first determines the tooth movement required from prescription provided by doctor, required force systems and then designs the appliance for patient.¹² Often refinements are required to tailor the appliance for individual patient as the software will not be able to do on its own. Hence along with experience of the orthodontist, sound knowledge of the system is utmost important to achieve finest results for each patient.

5. Conflict of Interest

None.

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