Thermoplastic Aligners

Nabeel F Talic, BDS, MS, PhD, FICD
Associate Professor and Consultant Orthodontist
Department of Pediatric Dentistry and Orthodontics
College of Dentistry
King Saud University

Invisalign Timeline Development

1997
- The company was founded in 1997 by Zia Chishti
- He partnered with Kelsey Wirth to seek developers

2002
- Zia Chishti was ousted from Align Technology

2005
- Zia Chishti developed Orthoclear
- A similar product, which resulted in several legal disputes involving allegations of patent infringement

2006
- The case was settled. Align paid OrthoClear $20 million and OrthoClear agreed to end its operations.

2009
- ClearCorrect filed a declaratory judgment against Align Technology.

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Clear Aligner Therapy

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Clear Aligner Therapy

Merits:

1. Cosmetic procedure transparent and difficult to detect

2. Easy to wear and remove the appliance

3. No need for adjustment of braces every month

4. Fewer appointments spaced at greater intervals as the patient is provided with preformed aligners

5. No fear of detachment of brackets and wire injury as in conventional braces

6. No potential metal allergy reactions associated with conventional fixed appliances

7. The virtual treatment model can serve as a motivation tool for the patient

Clear Aligner Therapy

As they are removable, not continually correcting the teeth.

Largely dependent on the patient's habits and their consistency in wearing.

Removal and re- insertion each and every time during eating.

Limited intermaxillary correction.

Additional time and documentation required if changes have to be made once the treatment has started.

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invisalign®

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Invisalign Production Process

- **Diagnostic records for such treatment are not different**
- **Use articulating paper to mark the occlusal contacts when taking photographs**

Alginate Hydrocolloid

Table 12.1 Components of an alginate impression material powder and their functions

Components	Function
Diatomaceous earth or other filler	Control consistency before setting, and flexibility after setting
Potassium alginate and calcium sulfate	Form alginate gel
Potassium sulfate or other gypsum-modifiers	Counteract the inhibiting effect that the set impression has on the setting of gypsum
Sodium phosphate	Initially prevents the calcium ions from reacting, thus extending working time
Ammonium salts and chlorhexidine	Provide disinfection
Glycols	Render the powder dustless
Other	Provide taste and color

From Craig, 1997

Alginate Impression Material

Advantages

- Easy to manipulate
- General acceptance by the patient
- Hydrophilic
- Cost effective

Disadvantages

- Low tear strength
- Dimensional instability
- Can not be used to pour a second model

Invisalign Production Process

- **Intra-oral scan or PVS (Polyvinyl siloxane) is needed**
- **A bite registration is not necessary**

Rubber Impression Materials

- **Polysulfide rubber**
- **Silicone rubber**
- **Polyether rubber**

Condensation Silicone Rubbers

- They polymerize by condensation and form alcohol as product
- Liberation of alcohol can affect the dimensional stability, so immediate pouring indicated
- This material is hydrophobic so pouring a stone model with no surface imperfections is difficult
- So it should not be used in Orthodontics

Addition Silicone Materials

- These are polyvinylsiloxane (PVS) impression materials
- They have a moderately low-molecular weight silicone that contains silane groups
- Since addition silicones do not produce a volatile by-product during polymerization, very small dimensional changes occur on setting.
- Its highly elastic and stable polymers
- They liberate some hydrogen upon setting but it has no effect on the dimensional stability

Pentamix™ 2 Automatic Mixing Unit

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Addition Silicone Materials

Desirable Features

- Low viscosity – injectable
- Heavy viscosity – tray
- Automix, easy to use
- 4-minute working/setting time
- Ability to be disinfected
- Adequate shelf life
- Cost-effective
- Distinctive color contrast between light- and heavy-body viscosities

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Table 12.3 Components of polyvinylsiloxane impression pastes and their functions

Component	Function
Base siloxane oligomer	To provide inherent chemical and mechanical properties in the set material
Oligomer with terminal vinyl groups	To react with the base oligomer to form a cross-linked elastomer
Platinum acid catalyst	To catalyze the polymerization reaction
Filler	To improve the clinical handling characteristics

From information in Craig, 1997

Advantages of Polyvinylsiloxane Material:

- **Good handling of the material before setting**
- **Excellent dimensional stability**
- **Ability to form more than one model**

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Table 12.4 Comparison of properties for alginate and polyvinylsiloxane impression materials

Property	Impression Material	
	Alginate	Polyvinylsiloxane
Working time (min)	1.25–4.5	1–4
Setting time (min)	1.5–5.0	3–6.5
Recovery from deformation (%)	98.2	99.5–99.95
Strain in compression (%)	8–15	1–6
Tear strength (g/cm)	380–700	1500–4300

From Craig, 1997

Polyether Rubber

- **Has a polyether oligomer with reactive ring end group**
- **Good mixing of the material is required to avoid irritation of soft tissues by the ester**
- **Its dimensionally instable unless kept dry**
- **It has bitter taste**
- **High cost**

Invisalign Production Process

The intra-oral scans are used to create an accurate 3D digital model

Invisalign Production Process

At the digital treatment facility, the teeth are digitally sectioned, the dental archs are related to each other, tooth movement is staged based on doctor instructions and the treatment plan is placed online for the Doctor to review as ClinCheck

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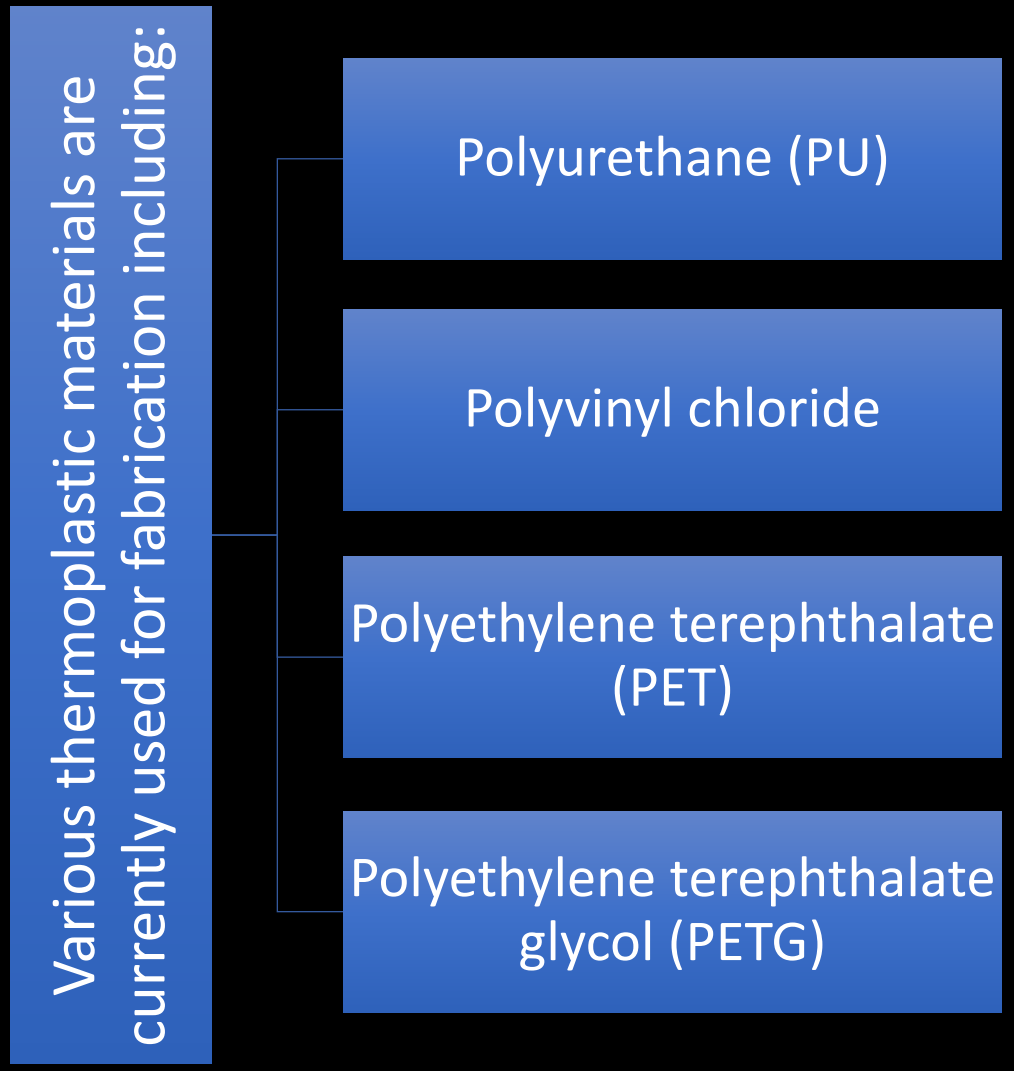
Invisalign Production Process

- **After approval, the digital models are transferred to a cast production facility where a stereolithographic model for each step is fabricated**
- **A clear plastic aligner is formed over each model**
- **A set of aligners are sent directly to the doctor**

Chemical Composition of Thermoplastic Aligners



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Chemical Composition

- **Polyurethane**
- **Biocompatible**
- **It is not an inert material**
- **As a rule, aligners are replaced every 14 days during treatment**
- **Each aligner is in the mouth for approximately 308 hours.**

Chemical Composition

- **The aligner is continually exposed to salivary enzymes, introduced liquids, inhaled and exhaled air and trauma caused by swallowing, speech and bruxism.**
- **Is sensitive to heat, humidity and prolonged contact with salivary enzymes. (Schuster S et. al.. Structural conformation and leaching from in vitro aged and retrieved Invisalign appliances. Am J Orthod Dentofacial Orthop 2004;126:725–8)**

The optical, chemical and morphological characteristics of the aligners after 14 days of wear

Micro-cracks

Abrasions

Localized calcified biofilm deposits and

Loss of transparency

Delamination or separation of the polyurethane material into layers can lead to significant loss of mechanical strength, and loss of transparency is a serious disadvantage from the patient's perspective

(Gracco A et al. Short-term chemical and physical changes in Invisalign appliances. Aust Orthod J 2009; 25: 34–40)

The optical, chemical and morphological characteristics of the aligners after 14 days of wear

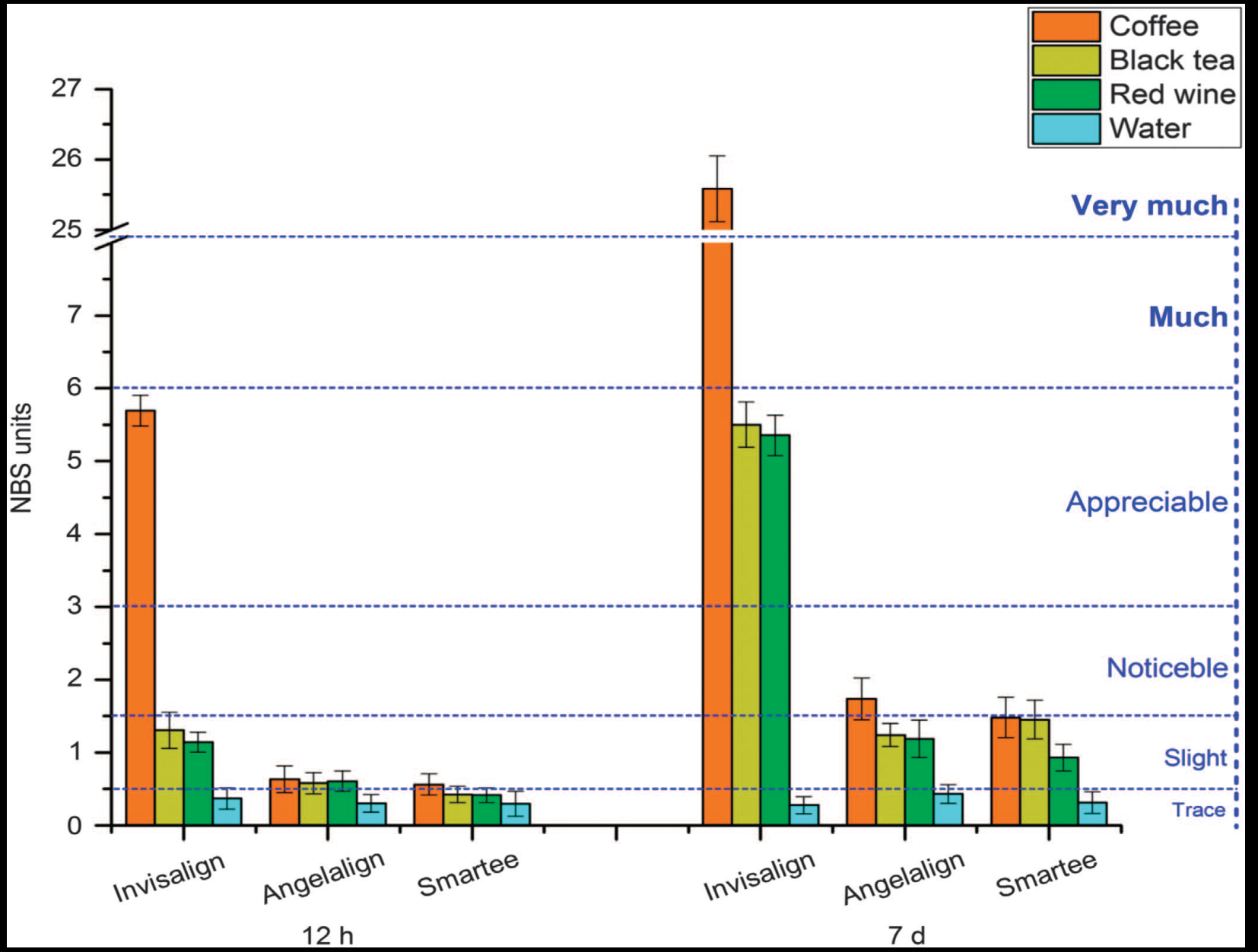
- **They found no evidence that monomers or by-products were released from the aligner suspended in artificial saliva for 14 days which suggests that the material is chemically stable**
- **They found evidence of molecular changes on the surfaces of the aligners**

(Gracco A et al. Short-term chemical and physical changes in Invisalign appliances. Aust Orthod J 2009; 25: 34–40)

Esthetic Appearance Stability

- The three types of clear aligners (Invisalign, Angelalign and Smartee) exhibited color stability after 12-h immersion
- The exception was the Invisalign aligners, which stained with coffee
- The Invisalign aligners were more prone to pigmentation than the Angelalign and Smartee aligners (PETG)
- Aligner materials may be improved in terms of their esthetic stability properties

Chen-Lu Liu et al. Colour stabilities of three types of orthodontic clear aligners exposed to staining agents. International Journal of Oral Science (2016), 1–8


Coffee
Black tea
Red wine
Water
NBS units
27
26
25
7
6
5
4
3
2
1
0
Very much
Much
Appreciable
Noticeble
Slight
Trace
Invisalign
Angelalign
Smartee
Invisalign
Angelalign
Smartee
12 h
7 d

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Systematic Review Article

Efficacy of clear aligners in controlling orthodontic tooth movement: *A systematic review*

Gabriele Rossini[a]; Simone Parrini[a]; Tommaso Castroflorio[b]; Andrea Deregibus[c]; Cesare L. Debernardi[d]

CAT aligns and levels the arches

It is effective in controlling anterior intrusion but not anterior extrusion

It is effective in controlling posterior buccolingual inclination but not anterior buccolingual inclination

It is effective in controlling upper molar bodily movements of about 1.5 mm

It is not effective in controlling rotation of rounded teeth in particular

Angle Orthodontist, Vol 85, No 5, 2015

SmartForce® Attachments

Optimized Extrusion Attachment	Extrusion	Upper and lower incisors and canines	
Multi tooth anterior extrusion	Extrusion	Upper incisors	

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SmartForce® Attachments

Optimized Rotation Attachment	Rotation	Upper and lower canines and premolars	
Optimized Root Control Attachment	Tipping	• Upper central and lateral incisors • Upper and lower canines and premolars	
Optimized Multi-plane Movement features	Extrusion ± crown tipping ± rotation	Upper lateral incisors	 

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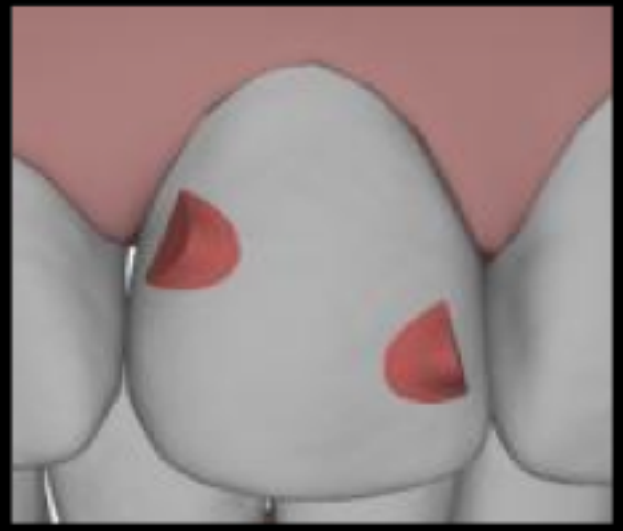
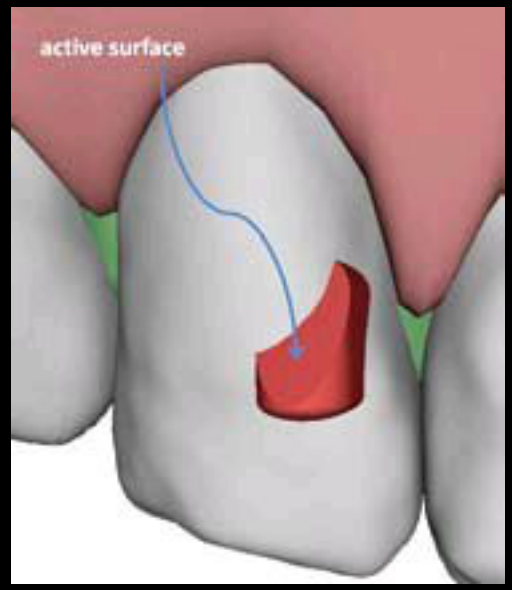
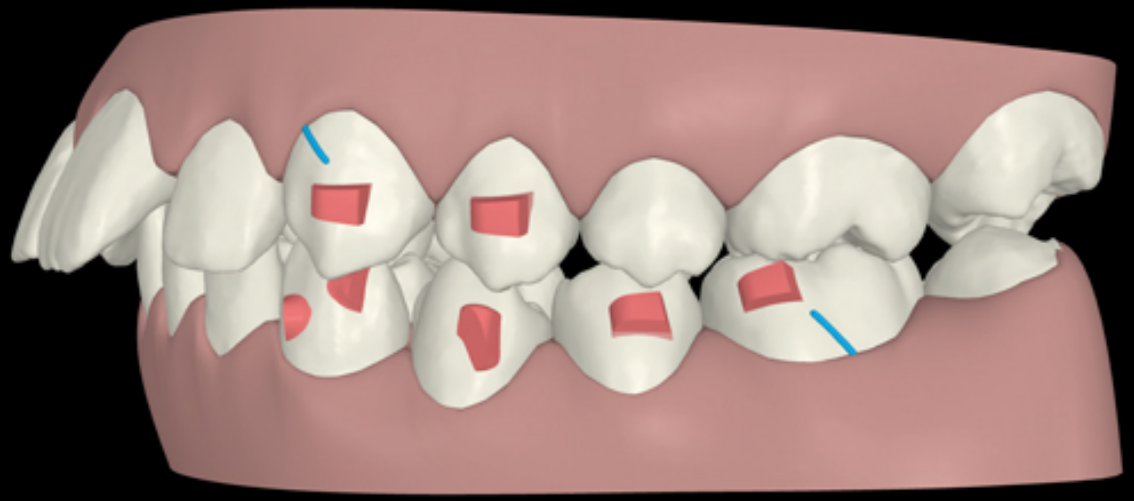
Active Surface of Attachments







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Clear Aligner Applicability

Perform Well

- Mild to moderate crowding
- Posterior dental exapansion
- Mild to moderate spacing

- Intrusion of teeth
- Lower incisor extraction
- Tip molar distally

Does not Perform Well

- Extrusion of incisors
- High canines
- Severe rotations

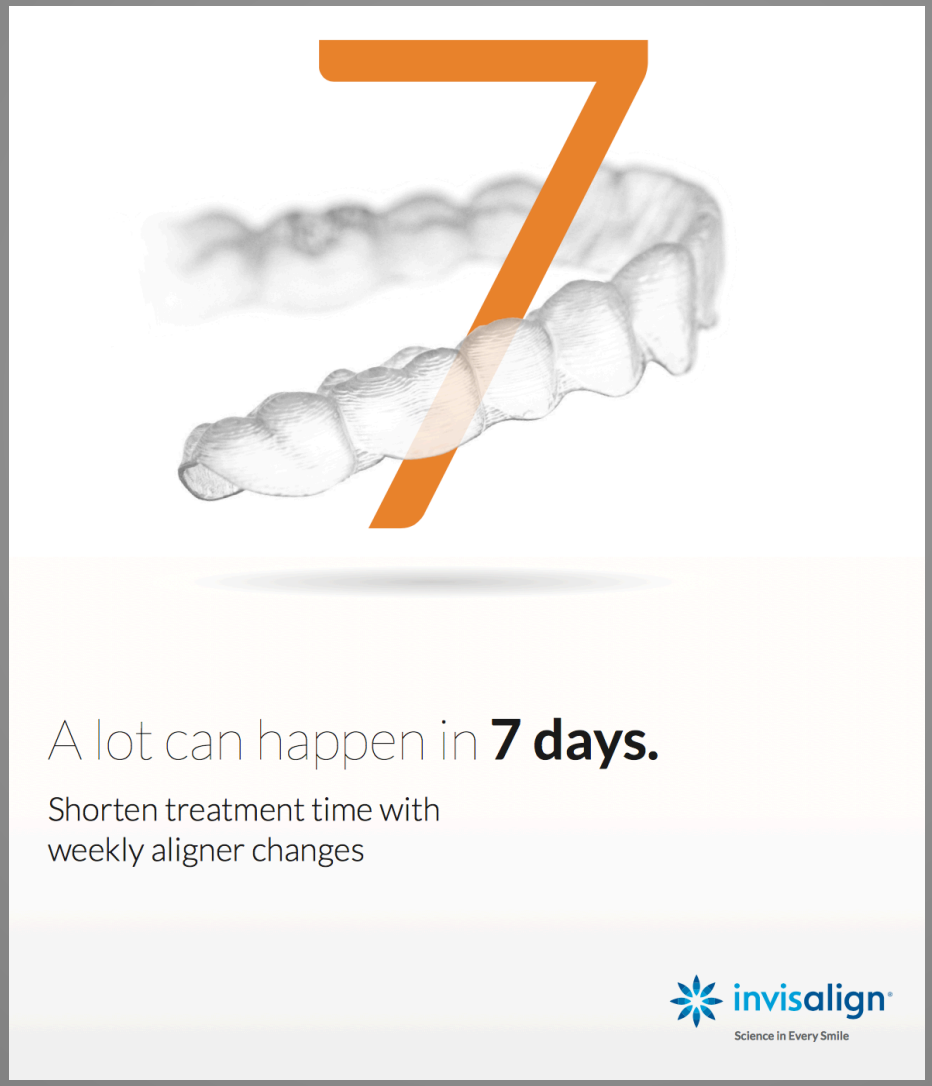
- Molar uprighting
- Closure of premolar extraction spaces
- Translation of molars

Clear Aligner Therapy

Limitations:

- **Severely crowded tooth or teeth**
- **Severe rotations**
- **Growth problems**
- **Impacted teeth**
- **Inter-cuspation cases**

New Developments



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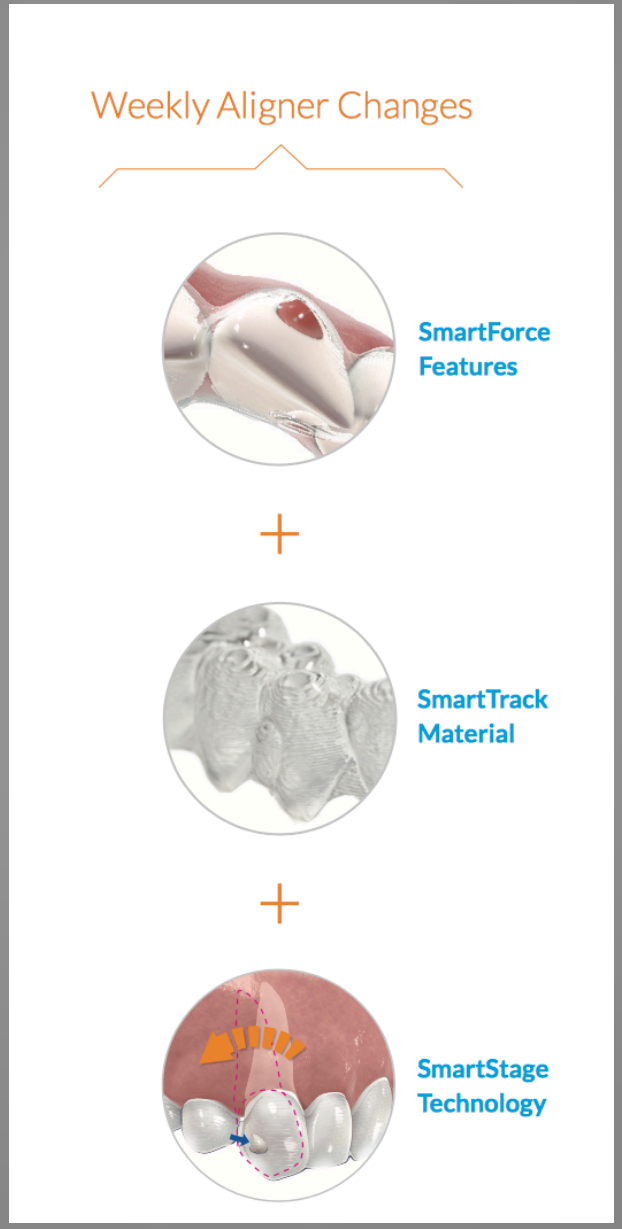
New Developments



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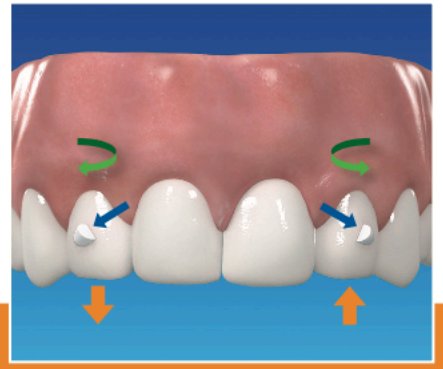
New Developments

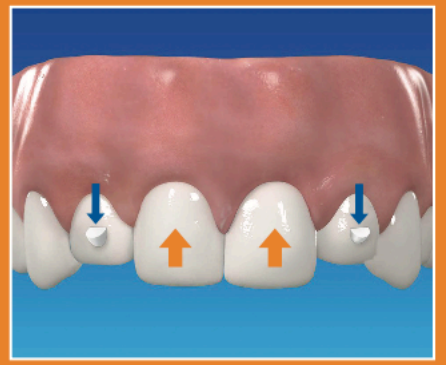


Enhanced Upper Lateral Control

Optimized multiplane attachments will allow better tracking of Upper Laterals when **rotation with extrusion or rotation with intrusion** is planned.

Enhanced Upper Lateral Control

The new **Optimized support attachments** on upper lateral incisors are engineered to deliver **improved tracking of upper laterals when neighboring teeth are intruding**.



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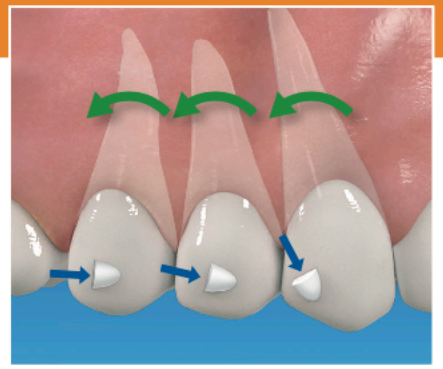
New Developments



Optimized Root Control

Invisalign G7 enables mesial distal root control for premolars
through a single attachment paired with SmartStage technology.

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New Developments

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