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Predictability of Successful Orthodontic Treatment Using Invisalign

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Agenda

- How does Invisalign work?
- Why now?
- Predictability of treatment
- Clinical tips

How does Invisalign work?

1. A rubber base impression (PVS) is sent to Align Technology with copies of x-rays, photos and a detailed treatment plan.
2. A model is made that is embedded in a high contrast material which is entered into the computer by laser scanning very thin slices of the model (destructive scanning)
3. Based on the doctor's detailed treatment plan, technicians generate a ***virtual correction*** of the malocclusion which is e-mailed to doctor (ClinCheck)
4. The doctor reviews the virtual treatment and e-mails revisions if necessary
5. Any revisions requested are made by the Align technician and e-mailed back to the doctor as a modified ClinCheck
6. After final approval, the treatment sequence is divided into a series of algorithmic stages which has maximum tooth movement of .25mm per stage
7. Models of each stage of treatment are made by having the computer direct their fabrication (stereolithography)
    - Laser guides curing of thin layers of resin
8. Individual appliances (aligners) are made from the computer generated models of each stage

Aligners

How is Invisalign used by the patient?

- Each set of aligners are worn for 2 weeks (occasionally more)
- Only removed for eating, tooth-brushing and flossing (elastic placing instrument helpful for removal if tight)
- Keep aligners clear with 10 min. soaking in 4 drops of sodium hypocloride (Clorox) and water

Is Invisalign really new?

- Kesling (AJO 1945) - showed tooth movement as a series of planned individual stages using set-up models for use with positioners
- Nahoum (NYSDJ 1964) - vacuum formed dental contour appliance
- Ponitz (AJO 1971) - used thin, clear overlay appliances for staged treatment
- Modified by McNamara et al.(JCO1985),Sheridan et al (JCO 1993), Rinchuse (JCO 1997) & Lindauer & Schoff (JCO 1998)

*Primary limitation of these methods is only **smaller magnitudes** of tooth movement are possible*

What is new?

- Laser scanning that creates an accurate 3D surface map of the teeth
- Software to simulate tooth movement
- Computer controlled fabrication of accurate models that reflect virtual stages of treatment

What this does

- Allows larger magnitudes of tooth movement in a controlled, continuous 3D environment

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Why now?

- Increased awareness for esthetics
- Many patients will place greater value on having more esthetic treatment
- Patients are more aware of plaque associated problems with fixed appliances
- Many patients do not want fixed appliances (especially adult males and re-treatments) due to fear of pain
- Appreciation of the benefits of technology (especially teenagers and young adults)
- Most orthodontic patients are computer literate and appreciate how technology can enhance treatment
- Invisalign website generates many referrals
- Alternatives to “cosmetic” bonding

Is demineralization from full-coverage plastic appliances a problem?

- Sheridan (JCO, July 2001) cites potential for demineralization based on observations
- Examination of pre and post treatment intraoral photos of 32 consecutively started patients did not show any measurable decalcification
- Plaque index of ten consecutive finished cases showed 22% reduction of plaque from pre-treatment levels on buccal surfaces
    - brushing was increased to avoid bad odor and lack of clearness on aligners (agrees with preliminary findings of Univ. of Florida Invisalign study)

Comparison of Invisalign vs. cosmetic bonding of porcelain veneers

- Cost is much less
- Periodontal and pulp tissue damage increase as crowding increases
- Long-term esthetic outcome and success if bonded to dentin of root not studied

Why was Invisalign released before controlled clinical studies were done?

- Invisalign is based on a CONCEPT which was very similar to other previously developed orthodontic appliances (Essix)
- As a rule, orthodontic companies release new appliances without having published any clinical studies

Is Invisalign as simple as it looks?

- Clinician must be able to visualize treatment results that are in harmony with all other hard and soft tissues
- Clinician should understand the correct direction of movement, sufficient anchorage, periodontal considerations and biomechanics involved
- Many new aspects of treatment techniques must be learned about Invisalign to be proficient with treatment of full malocclusions
- Significant learning curve for orthodontists (usually 15 to 20 class I cases with normal OB-OJ in order to effectively treat more difficult cases)
- It is really only simple for cases with minor spacing or anterior crowding and acceptable OB-OJ (similar to fixed appliances)

- Opinion: Invisalign requires greater skill and training to plan virtual tooth movement compared to conventional fixed treatment because the clinician must be able to plan the exact path to optimal results BEFORE treatment

Is the quality of results compromised with Invisalign treatment compared to fixed appliances?

- Only case studies published
- Invisalign is *one type of appliance* with *its own advantages and disadvantages*
- OPINION: As long as a case is selected which is within the experience level of the operator, and is appropriate for Invisalign treatment, then *similar* results to fixed appliances can be achieved

How important is the clinician's skill level?

- OPINION: If you are committed to excellent results with fixed appliances, you are likely to achieve excellent results with Invisalign (real issue is personal motivation for excellence)
- Invisalign is only as effective as the skill and motivation of the clinician
- You must treat to the standard of care of each patient
- If you do not know the standard of care for a patient, treatment should not be attempted

Agenda

- How does Invisalign work?
- Why now?
- **Predictability of treatment**
  - **Highly predictable**
  - **Moderately predicable**
  - **Less predictable**
- Clinical tips

Predictability of treatment: Highly predictable

- Especially with long clinical crowns and mature patients

1. Space closure
2. 2-4 mm of buccal or labial expansion
3. Stripping and incisor rotations
4. Lower incisor extractions
5 Deep overbite
6. Cross-bite correction (non-skeletal)

How well do patients comply?

- Usually excellent because ***slight posterior open bite*** that occurs 3-4 weeks after treatment starts
  - **causes heavier contact on anterior teeth** when not wearing aligners
- This is overcome with aligners in place because the patient then has even contact of the entire arch
- Additional finding is that **patients rarely have muscle soreness** (double splint effect)
  - can be used in patients with history of myofacial pain from parafunctional habits (tooth wear also avoided during treatment)
- The alternative of using fixed appliances usually motivates patients

Patient discomfort with Invisalign vs. fixed appliances

- Generally much less with Invisalign because of smaller increments of movements (0.25mm max.)

Stripping, Incisor Rotations, and Mild Expansion (1-4 mm)

- Early findings = 9/10 corrections
- Solution is ***overcorrection*** *(11/10 at time of ClinCheck)*

Interproximal reduction (stripping)

- Best to do majority before tooth movement in conjunction with incisal edge reshaping
  - Avoids over-expansion ("round trip")
  - Eliminates difficult step of matching computer interproximal reduction
  - Requires night time clear retainer to maintain tooth position until Invisalign treatment begins
  - Allows bleaching to begin before active treatment begins

Stripping

- New interproximal reduction kit from Align (Dr. Eric Kuo) is extremely helpful
  - contains burs, measuring tools, describes techniques, and offers many helpful clinical suggestions
  - includes Dr. Sheridan's ARS manual

Armamentarium

- Diamond disks
- Diamond burs(needle)
- 1169L's(Fissure burs)
- Lightening strips
- 1 week of separation if difficult access
- Softlex disks

Technique (for adults with full anatomic crowns exposed-less reduction for teenagers)

- For **most cases**: 1-3 mm space available in the lower anterior
- For 4-5 mm strip to mesial of second molars
- can gain another 1-3 mm more if periodontal tissues have receded from bone loss leaving longer clinical crowns
- Bitewing, pano and PA x-rays are a guide to enamel thickness and interproximal bone height
- Space closure can be done as recommended by Dr Jack Sheridan with Invisalign by turning crowded cases into space closure cases –if protrusion exists, can close most posterior spaces first which imports this space to the anterior areas for additional space
- When explaining stripping always tell the patient that **<u>tooth extraction can be avoided</u>** this way
- Important to explain to patient that crowded teeth have not had any proximal wear and the **stripping procedure will only remove the same amount that would have worn away on its own** by the time the patient is an adult

Interproximal reduction limitations

- *Enamel thickness of the posterior dentition:Its implications for nonextraction treatment*
  - Stroud et al. AO 1998
- Distal enamel was significantly thicker than mesial enamel
- Assuming 50% enamel reduction, the premolars and molars should provide 9.8 mm of additional space for realignment of mandibular teeth

Does interproximal reduction result in increased caries or periodontal disease?

- Conclusion: No increase in caries or periodontal disease
  - <u>Reproximation (enamel stripping) as an essential orthodontic treatment ingredient</u>. Peck & Peck. St. Louis: Mosby, 1975
  - *Anterior interocclusal relations: Part 1,* Tuverson, AJO 1980;78:361-370

- *The effects of interdental stripping on the labial segments evaluated one year out of retention*, Betteridge, Brit J Orthod 1970:240-249
- *Self-alignment following interproximal stripping,* Paskow, AJO 1981;8:193-197
- A study of the effects of mesiodistal reduction of mandibular anterior teeth, Hudson, AJO 1956;42:615-624
- *Susceptibility to caries and periodontal disease after posterior air-rotor stripping,* Crain & Sheridan, JCO 1990;24:84-85

Stripping

- Best Bur: Brasseler Diamond #859-010
- Leaves edges rounded compared to disks

Lower incisor extractions

Attachments

- If you are closing extraction spaces, consider long thin attachments on the adjacent teeth that will require bodily movement
  - usually **4-5 mm x 1 mm x 1 mm**
- Attachments are placed on computer model by technician, but can be modified by doctor at time of ClinCheck
- A .010 mm template is made at stage 0 to place attachments
- With .010 mm template, add **restorative composite (not bracket bonding agents as they wear too quickly)** to create actual attachment
- Isolate, etch and seal area of tooth to receive attachment
- *Light cure* attachment
- Remove only flash and **do not smooth off the edges of attachments** as you will lose contact with aligner which lessens control of tooth movement

If attachment breaks off

- Patient should call for appointment AS SOON AS POSSIBLE
- Section tooth from previous aligner or template and re-bond
- If tooth develops space from loss of control, will probably need to go back 1 or 2 stages

Predictability of treatment: Mod**e**rately predictable

1. Root torquing
2. Distalizing posterior teeth
   - up to 3-4 mm
   - may need class II elastics
3. Use in periodontally compromised patients
4. Mature teenagers (> 14 yrs.) with fully errupted teeth
5. Closure of mild openbite with retraction of incisors (non-extraction)
6. Closure of moderate openbite with incisor retraction in extraction treatment

Problems with non-movement

- Interproximal area may be tight - check with floss
- Strip interproximal as needed to have slight space between teeth for teeth undergoing movement
- When contact of tooth to aligner is missing, no movement occurs
- When contact of tooth to aligner is missing, no movement occurs as space exists between aligner and tooth

How are forces programmed into aligners?

- A simple trigonometric calculation demonstrates how a 4.6 degree rotation corresponds to 0.2 mm movement of the outermost point of a lower incisor (assumed to be 5.0 mm wide)

How are forces applied with Invisalign?

- Preliminary finite element studies show that forces are dissipated over the majority of the crown which tends to distribute the forces over more of the root surface than with fixed appliances
- Effect on root resorption?

Overcorrections necessary

- Rotations
- Bite depth (deep or open)
- Torque
- Extraction spaces

Protocol for changing aligners

- Recently Align developed a more rigid standard for magnitude of tooth movement which now requires TWO WEEKS for each Aligner
- May be more than *two weeks* per aligner in extraction cases with bodily movement, for patients who wear Aligners less than 22 hrs/day, or if problems occur with Aligner seating completely
- **Patients should keep the last 3 to 4 Aligners** in order to go back to a stage that fits if seating problems occur

Invisalign retention protocol

- Full-time wear 5-6 months (can do additional minor treatment or over-correction)
- To close posterior bite (>85% of patients have this)
  - cut aligners distal to occlusal contacts (usually 1st or 2nd premolars) and let settle 2-4 week
  - Then wear while sleeping only (usually **indefinitely)**

Class II occlusion correction with Invisalign

Requires a modified approach to mechanics for A-P correction

- Consider intra-arch movement using other teeth as anchorage to achieve inter-arch corrections (i.e.,distalization of molars in a class II)
- It is also **possible to place inter-arch elastics on aligners** to correct mild A-P problems, increase anchorage & correct midline discrepancies

Cementing hooks to aligners (purchase kit from AlignTech)

- Place attachment on aligner with cement
- Light cure
- Test hooks before using

Anchorage considerations

- Enhanced anchorage through non-movement (splinting effect) of the anchorage segment
  - "Stationary anchorage", B. Melson (CO&R, 2000)
  - Decreased cellular activity of tissue not undergoing treatment
- Recent improvement in software staging efficiency have programmed in more effective anchorage control
- Good rule for checking the adequacy of anchorage control is to have *> 3 times the root surface area as anchorage at any given tim*

Predictability of treatment: Less predictable

1. Severe rotations of premolars and lower canines
2. Extrusion with no retraction
3. Mesial movement of posterior teeth (pre-molar extractions)
4. Short clinical crowns (partially erupted teeth)
5. Less mature teenagers

Extrusion of one or more teeth

- Requires placement of composite attachments
  - new attachments in development
- Aligner must completely cover attachment and have 2 mm space GINGIVAL to attachment with aligner well adapted
- **Monitor at closer intervals**
- **Must have slight interproximal space** check with floss (stripping as necessary)

Extrusion of teeth

- Extrusive movements still challenging even with attachments
- Relative extrusion (tipping crown lingually) is effective
- Absolute extrusion is difficult (sign release to treat)
- If extrusion is desired, program movements at end of treatment to avoid midcourse reboots
- Failure noted by space between aligner and tooth

Clinical tip for extrusion

- Extrude teeth with an elastic from a button on facial of tooth and lingual of aligner

Use of segmental wire concurrently with Invislign for extrusion or individual root movement in premolar extraction cases

- Cut away aligner at gingival 1/3and bond small size clear bracket (lower ant.) to tooth which will be extruded and one adjacent tooth on each side
- Place segmental archwire that has both ends bent down around bracket
- If moving root, place gable bend or use full size TMA rectangular wire and figure 8 tie with elastic thread
- **Important to wear aligner to control arch form during this time**

Placement of attachments at extraction sites to prevent tipping

- **4 - 5 mm x 1mm x 1mm rectangular shaped attachments** placed on enamel as dentin bond is weaker
- **Use posterior composite material**
- Should have 2 mm tooth structure gingival to attachment
- Tight fit of aligner gingival to attachment
- Do not smooth off sharp edges of attachments
- Aligner should cover 100% of anatomical crown for optimum control
- **Use marking pen to show position of attachment to patient** when Aligner is in place
- **Patient must monitor fit of attachment** in the Aligner (if they get off track, them they go back 1 to 3 stages and treatment takes longer)

Attachments for premolar extraction cases

- Greatest problem with premolar extraction cases is **poor adaptation of aligner material on the mesial surface of posterior teeth facing the extraction site** this is why attachments are necessary, i.e., to hold teeth upright to achieve translation
- Molars should have ***two*** 4-5mm x 1mm x 1mm attachments to prevent tipping
- Premolars should have similar attachments with **one on the buccal and one on the lingual**

- **Patient should know that segmental fixed appliances will most likely be necessary for the last 5 to 7 aligners as "helpers" to move the roots**

Additional Clinical tips

- **Use auxiliaries for most chair side procedures** (PVS impressions, placing and removing attachments, determining if aligners fit well, etc.)
- Make sure impression captures entire crown
- **Avoid short clinical crowns**
- Avoid restorative dentistry during treatment
- Diagnose centric relation prematurities

Over-correction

- Automatic at ClinCheck unless you do not request it
- May not use all of overcorrected Aligners (mark with bold ID)
- Patient may become concerned if teeth assume overcorrected positions

Case refinement

- Always request this
- Separate form
- Criteria is if all goals have not been achieved but aligners fit well at end of treatment

Mid-course correction

- Separate form
- Necessary if Aligners do not fit well **even after going back 1-3 stages and increasing wear time**
- Requires **new PVS impressions**
- New ClinCheck sent in 1-2 weeks, then new manufacture (2-3 weeks)
- Extra charge if this is due to patient non-compliance or restorative changes in tooth anatomy

Aligner not seated at delivery

- Wear aligner or template 1-2 weeks before placing attachments
- Avoid under extended Aligners (loss of control and poor bleaching)

Pre-treatment bleaching

- Check with general dentist first
- Starts treatment in positive manner
- Use **30% (zero clearance**) carbamide peroxide 20 minutes per shade of whitening
- Place **thin layer** on labial surfaces
- Add at no charge
- Complete before placing attachments

Bleaching during treatment as patient wishes with 30 % gel

Bleaching sensitivity (approx. 20-30%)

- Use Colgate Sensitive - 2-3 times/day
- Contains potassium nitrate & stannous fluoride
- Rembrandt – 30 % bleaching system that also desensitizes

Encourage use of other whitening products

- All whitening toothpastes have similar effectiveness and act by removing stain but not by bleaching
- Stain removing floss may also be effective
- Find out if referring dentists have in office bleaching available-many patients prefer this because it is quick and only 1 visit usually

Laser removal of dark gingival pigment can be done

Adding a "virtual" tooth in extraction cases

- Virtual tooth narrows in width as extraction space closes
- Request composite kit from Align
- Injectible, light-cured soft resin bonded to aligner

Aligner materials (0.30")

Exceed-30

- More flexible (easier to use with attachments)
- Rarely breaks
- Replaced PC-30
- Remains clear

* Exceed-40 used for retainers

Aligner cleaning

- Brush with toothbrush (powered better)
- Soak 5 minutes with new Align dissolving tablets or 3-4 drops of Clorox (both sodium hypochlorite)
- Align sells a sonic vibrating cleaning unit for approx. $50. USD

Total treatment time: Doctor

Invisalign vs. Fixed (equivalent difficulty)

Task	Time
Consultation	Same
Treatment plan	Greater
Adjustments	Much less
Stripping	Same
Retention	Less

Total treatment time: Assistant

Invisalign vs. Fixed (equivalent difficulty)

Task	Time
Records	Greater
Hygiene instructions	Less
Adjust appliance	Much less
Remove appliance	Much less
Retention	Less

Orthodontic assistant's role

- Provide information at all visits
- Records and PVS impressions
- Place and remove attachments and excess composite flash around attachments
- Initial try in and instructions (use cotton rolls)
- Check patient initially at 2-3 weeks and then again at 6-8 week intervals
- Manage retention procedures (set ups, try-in compliance, etc.)

Phone scripts necessary

- Makes shorter and more successful initial consultation
  - if detailed questions, use most experienced assistant
  - Use Aligns resources given through your rep to help with this

Total treatment time - Compare fixed vs. Invisalign for equivalent (minimal to moderate) difficulty

- Treatment duration similar to fixed
- **Similar # of patient visits but much shorter chair time**
- Doctor and assistant time much less
  - working patients appreciate less chair time and " mouth open time"
  - shorter visits easier to schedule at preferred times

Presenting fees for *predictable* treatments*

- Show patient fixed and removable appliance models and ask them to feel the difference
- Give usual clear bracket fee and Invisalign fee (should be only $500 - $1000 USD more if you are sure no fixed appliances are necessary)
- Explain bleaching as a no-cost, value-added benefit (approx. $400-$500 USD usually)
- For patients likely to receive adjunctive fixed and Invisalign treatment, explain cost differential

* Unlikely to need fixed

Materials and supplies costs - Percentage of overhead (average)

	Fixed	Invisalign
Infection control (sterilization)	12%	much less
Instruments	4%	much less
Wires, brackets & bands	18-20%	rarely needed
Impression trays & material	1-2%	higher
Lab fees (study models, retainers, etc)	4-5%	significantly higher

Summary - Caveats

- If the patient does not wear an aligner for *more than 2-3 weeks*, new PVS impressions and re-scanning may be necessary
- If patient loses an Aligner, they should try the next aligner (wear for one month) or use the previous aligner and call to report this ASAP ($50 cost per Aligner)
- Patients may resist finishing with fixed appliances if necessary (if fixed appliances needed, better to do *before* Invisalign)
- Significant learning curve for complex cases (at least 15 cases)
- Overly enthusiastic patients proceed to the next aligner too quickly and get off track
- Appliance manufacturing lengthy (6-7 weeks) but improving
- Need for PVS impressions
- Use one step products (Caulk - Aquasil, Heraeus - Flexitime)
- May be replaced with single, low radiation x-ray in the future or intraoral scanners

Summary - Advantages

- Esthetic-rarely noticed even at close distance - attracts additional patients
- Better cooperation than fixed
- Better hygiene than fixed
- Possible to treat “brittle” perio problems
- No decalcification
- 3D control of tooth movement
- Shorter appointments
- Decreased doctor & auxiliary time - emergencies rare
- Decreased allergic response (no metal or latex) - aligners are made from polyvinyl material approved as an internal implant material
- Controlled overcorrection possible
- Can close anterior openbite
- Less damage to existing restorative dentistry (especially porcelain) and tooth structure than fixed appliance
- Retention facilitated (does not require a new patient experience)
- Ideal for re-treatment
- Decreased occlusal abrasion from para-functional habits during treatment
- Technically much easier than lingual or clear appliances
- Ability to present case to patient with final result prior to treatment
- Ability to review treatment progress during treatment to increase compliance
- Provides a record of projected results which enables future review
- Disappearing patients have very minimal potential for periodontal or caries damage
- Ability to present case to patient with final result prior to treatment
- Ability to review treatment progress during treatment to increase compliance
- Disappearing patients have very minimal potential for periodontal or caries damage
- Ability to take a pause in treatment - better management of delinquent accounts

Other current Align studies

Controlled clinical studies:

- University of Washington (Dr. Greg King) Determining optimal reactivation time and materials for most efficient tooth movement-unfortunately studied methods and techniques not used anymore so it probably will not be published
- University of Florida (Dr. Tim Wheeler) Optimum use of attachments-100 patients being followed closely

Literature

- R. Boyd, V. Vlaskalic and R. Miller--Journal of Clinical Orthodontics (April 2000)
- R. Boyd--PCSO Bulletin (Winter 2001)
- V. Vlaskalic and R. Boyd--Australian Journal of Orthodontics (June 2001)
- R. Boyd--Compendium (Spring 2001)
- R. Boyd and V. Vlaskalic--Seminars in Orthodontics, W.B. Saunders (Dec. 2001) “3D Diagnosis and Treatment In Orthodontics”
- J. Nelson, PCSO Bulletin, Winter 2001
- Vlaskalic and Boyd—Journal of the California Dental Association (in press)

Cases & commentaries in orthodontic technology

- Orhan Tuncay, DMD, Chair, Department of Orthodontics, Temple University School of Dentistry
- Very helpful review of recently completed cases by experienced orthodontists