Clinical Success

in

Invisalign

Orthodontic Treatment

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QUINTESSENCE
International

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Invisalign Orthodontic Treatment

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Paris, Chicago, Berlin, Tokyo, London, Milan, Barcelona,
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- Dr A. Decker and his scientific and academic openness

The author would like to express his profound gratitude to all of them.

Preface

This book was written to provide the reader a tool for daily clinical use of the Invisalign system. It offers a summary of the author's 8 years of clinical experience treating several hundred patients with this esthetic alternative orthodontic system that makes use of individualized and industrialized thermoformed polycarbonate overlay appliances called *aligners*. Clinical results obtained from various treatment types are shown, from the simplest to the most complicated cases, using aligners alone or in combination with other techniques, eg, fixed and surgical orthopedics or orthodontics.

The Invisalign system is unique in that, in order to obtain an optimal result, the clinician must be capable of planning in advance, even before the onset of treatment, the totality of the treatment plan. The fabrication of a series of aligners then follows, corresponding to the desired treatment objectives. This system requires considerable knowledge of orthodontics and biology to establish a sound diagnosis, as well as an understanding of the biomechanics of the appliances to ensure satisfactory movement of teeth and maxillary and mandibular bone.

To move teeth, orthodontists initially used removable and later fixed appliances to control and minimize undesirable tooth movements in three-dimensional space. The Invisalign system, in which the aligners have intimate contact with nearly the entire surface of the tooth crown, attempts to bring together the best qualities of removable and fixed appliances. Moreover, it provides an esthetic touch and undeniable comfort as well as easy oral hygiene access for patients.

The computer-assisted design of tooth movements (performed in a program called *ClinCheck*) to be carried out by the aligners gives orthodontists a new and fascinating way to treatment plan: programming in advance every desired movement according to their own diagnostic practices, treatment insight, and knowledge of the aligners' biomechanics. According to their diagnosis and treatment plan, orthodontists can use ClinCheck to control:

- Velocity and direction of tooth movements
- Amount and frequency of force to be applied to these movements

• Anchorage and available space necessary for the planned movements

Through precise clinical cases, this book provides tools for ClinCheck application and management of space and anchorage required for desired tooth movements. It is not meant to be exhaustive, but rather a clinical introduction to this comfortable and effective orthodontic treatment concept.

The Invisalign Concept

1

Fig 1-1 *(a to c)* Aligners are easy to insert, comfortable, and minimally visible.

What Is Invisalign?

- Invisalign is a minimally visible method for moving teeth without band, wire, or bracket.
- Invisalign therapy consists of a series of clear aligners that are worn to gradually move teeth (Fig 1-1).
- An Invisalign aligner is a custom-made, removable, comfortable dental retainer made from thermoformed medical polycarbonate, which is inert and compatible with human saliva. (See following section for details on thermoforming.)
- Each aligner is worn approximately 22 hours a day over a 2-week period for a total of over 300 hours. This leaves 2 hours a day for eating and toothbrushing.
- Aligners are replaced every other week on average to allow for gentle tooth movement over time according to the clinician's diagnosis and treatment plan.
- Treatment duration, which can range from 3 to 30 months, and cost depend on the extent of tooth malpositioning and malocclusion.

The Science of Invisalign Aligners: Thermoforming

Thermoforming is the art of shaping thermoplastic materials with heat. Chemically, plastics consist of polymers that are made up of numerous monomers, which are organic molecules with nuclei that contain one carbon atom. Examples of natural polymers include proteins, rubber, collagen, and cellulose. The behavior of plastics mostly depends on the type of structure developed by polymerization of constituent monomers. To optimize their

behavior, additives can be used to modify physical and chemical properties, and reinforcements can be added to modify mechanical properties.

In orthodontics, plastic materials in the form of soft, resilient round or square sheets (Fig 1-2) possessing excellent modeling properties are often used. These materials are inert, unaltered by saliva, and resistant to daily cleaning detergents. In addition, they are transparent, nontoxic, odorless, and tasteless.

Scheu et al proposed the first thermoforming machine to synthesize orthodontic appliances in 1966. Currently, two types of thermoforming machines, the Ministar and Biostar (Scheu Dental) (Fig 1-3), are available. Based on the principles of Scheu et al, Align Technology developed a large-scale, custom-made thermoforming system, which continues to undergo development and improvement (Fig 1-4).

Fig 1-2 Thermoformable plastic sheets used clinically.

Fig 1-3 Biostar series IV.

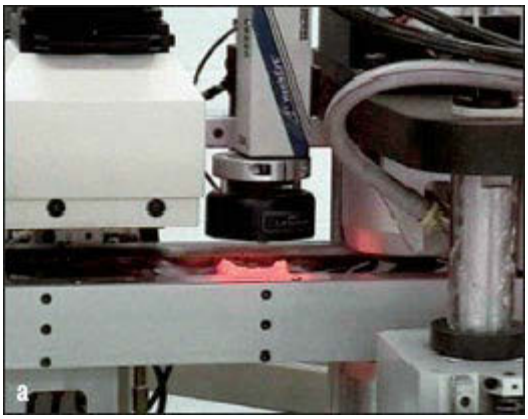


Fig 1-4a Thermoforming.

Fig 1-4b Automated sculptor of aligners.

Development of Align Technology

Design for the thermoforming system began in April 1997 when two MBA students from Stanford University, Zia Chishti and Kelsey Wirth, with the aid of a computer specialist, founded Align Technology in a garage in Palo Alto, California.

Chishti, who had suffered a relapse of mandibular incisor crowding after undergoing fixed orthodontic treatment, was required to wear a retainer to realign his mandibular anterior teeth. Disappointed by the relative slowness and limited progress of the relapse correction, Chishti conceived a revolutionary treatment concept: moving teeth with multiple appliances, whereby each tooth movement would be progressively conceptualized in three dimensions and virtually simulated by computer-assisted design software.

Appliances would be mechanically fabricated under computer control through a stereolithographic process to create resin models for each stage

of desired tooth movement. These models would then be combined with thermoformed polycarbonate sheets, which would allow for mass-produced, custom-made aligners for orthodontic treatment.

This new concept for orthodontic treatment combined orthodontic principles of tooth movement, 21st century three-dimensional (3D) computer-aided design/computer-assisted manufacture (CAD/CAM) technology, and computer-assisted, mass-prototyping industrial processes, ultimately leading to the development of the Align Technology company and the current Invisalign treatment concept and techniques.

This new system gained clearance from the Food and Drug Administration in 1998. It was presented at the American Association of Orthodontists conference in 1999 and arrived in Europe in 2001. By broadening the range of applications, Invisalign has introduced a new method of orthodontic therapy.

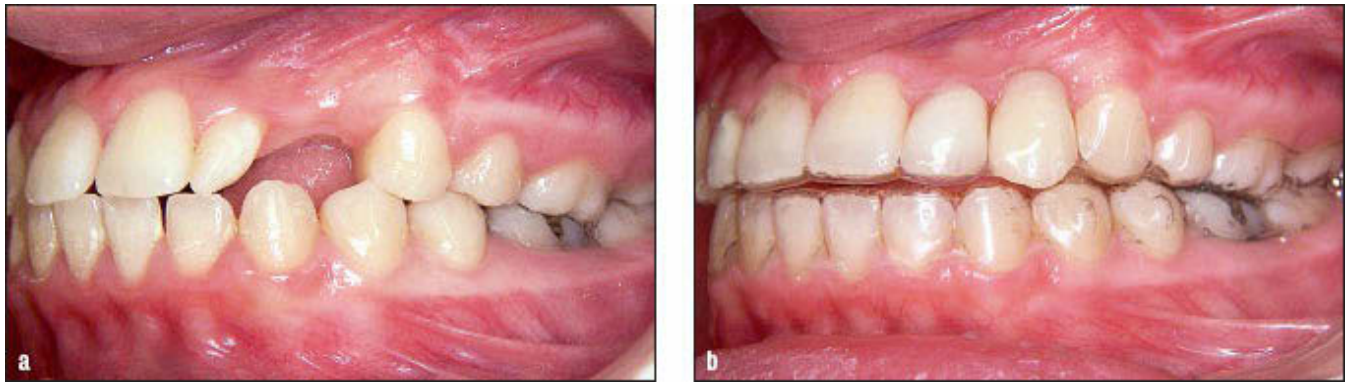


Fig 1-5 When a tooth is missing *(a)*, a pontic can be incorporated into the aligner *(b)*.

Fig 1-6 Storage container for the aligner.

Fig 1-7 Drug diffusion during treatment. (Courtesy of Dr J. Charon.)

Advantages of the Invisalign System

Minimal visibility

The transparency of Invisalign is a key feature and responds to the increasing demand from adult and adolescent patients for discreet orthodontic devices that are more suitable to social and professional life. In this way, Invisalign provides access to new patients who would otherwise decline treatment. Even patients with complications such as a missing tooth can benefit from Invisalign therapy. A prosthetic replacement tooth, called a pontic, can be incorporated into the appliance to replace an extracted tooth for esthetic enhancement (Fig 1-5).

Removability

During treatment, the patient can remove the aligners to eat or drink or for an important meeting. A storage container is supplied with the first aligner in the Patient Starter Kit (Fig 1-6).

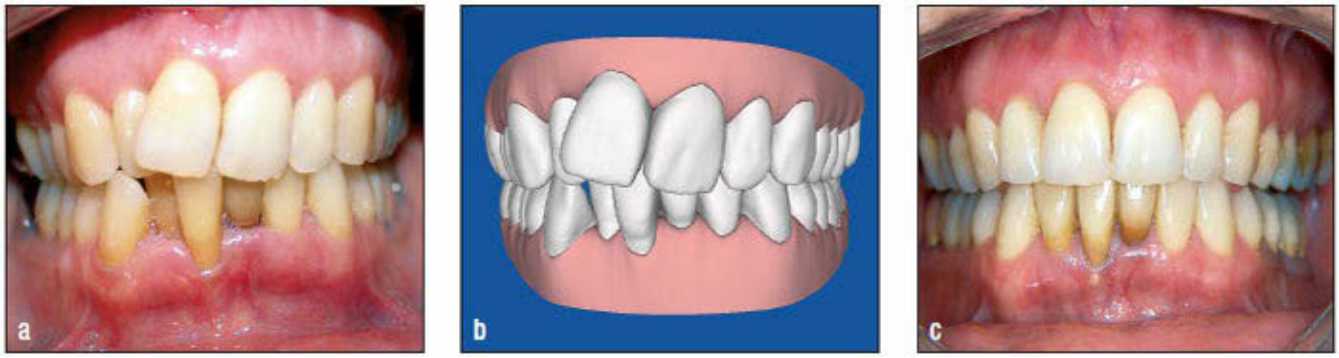


Fig 1-8 *(a)* Frontal view before treatment. *(b)* Computer image of clinical situation. The treatment plan included 60 maxillaryand 20 mandibular aligners. *(c)* Frontal view after 30 months of treatment.

Versatility

Toothbrushing and periodontal maintenance are well facilitated. Aligners can be inserted on natural or prosthetic teeth, definitive or provisional fixed prostheses (implant-supported or not), and resin and metal removable prostheses. Aligners can also serve as drug or chemical diffusers during orthodontic treatment and can administer substances such as toothbleaching products (Fig 1-7). To reduce periodontal risk, some periodontists recommend adding a drop of chlorhexidine gel at the molar region of the aligner. When the aligner is inserted in the mouth, the gel will flow and spread over the inner surface.

Comfort

Custom-made aligners adapt to teeth so that the margin coincides precisely with the dentogingival junction. Lips, cheeks, and tongue naturally slide along aligners as they would teeth. Fabricated by a precise industrial and automated process, aligners do not produce the irritation usually caused by the defects and irregular borders of appliances made by traditional methods. Wounds in the mouth caused by brackets, bands, wire, and other accessories of fixed appliances are also eliminated. Emergency treatment visits for rebonding of accessories or repairs of material breakage are also avoided.

Ease

Simple

The computer-assisted design process provides clear images of the progressive tooth movements, allowing the patient to easily understand the treatment plan and immediately visualize the progression of treatment (Fig 1-8).

Understandable

The virtual treatment demo offered through the program ClinCheck is an excellent communication tool: It allows for informed consent regarding treatment duration, type of tooth movements, number of aligners, and any necessary attachments or interproximal enamel reductions necessary for the desired outcome. Note: All ClinCheck protocols and features mentioned refer to those associated with the current version, ClinCheck 2.9.

Practical

The treatment principle is simple and unvarying: Each aligner is worn an average of 300 hours—22 hours a day for 14 days. In-office replacement requires few instruments and little time per visit.

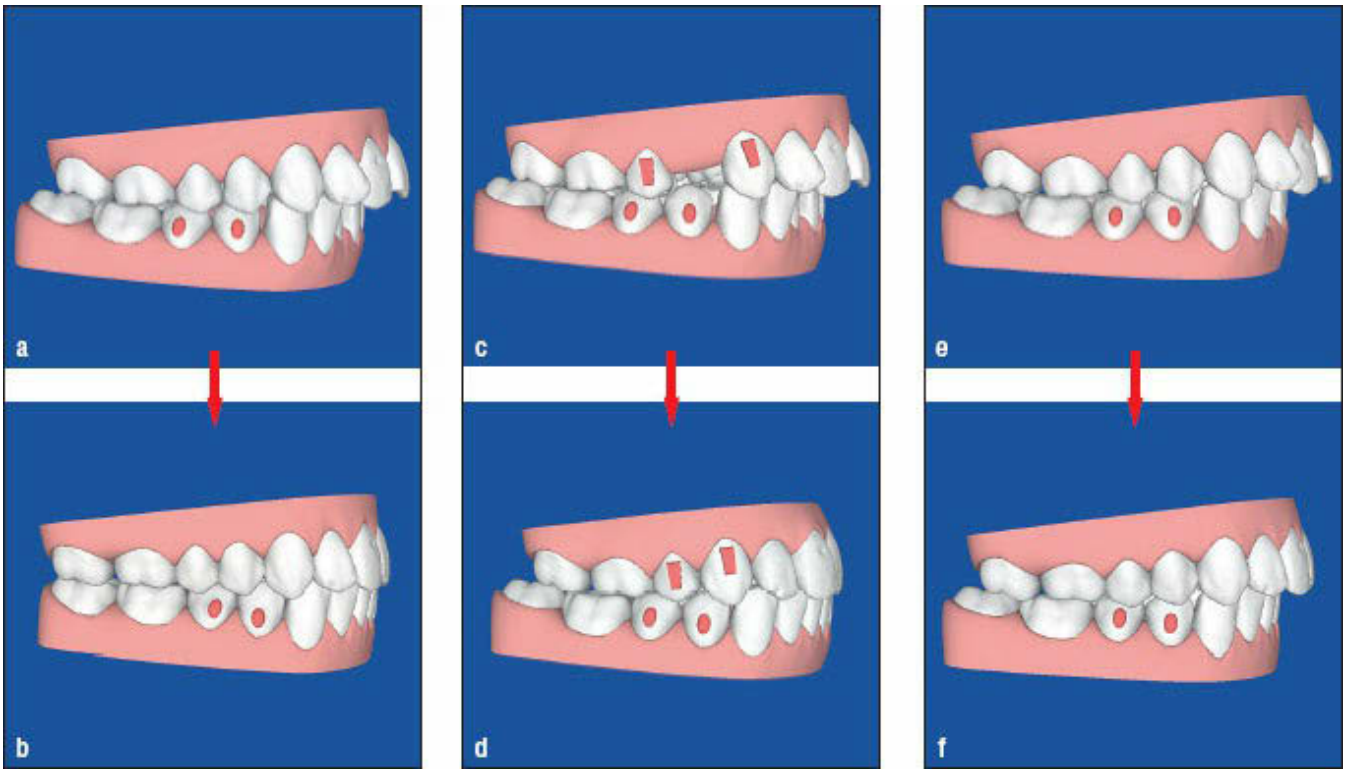


Fig 1-9 Simulations of three treatment options: Dista l izati on *(a and b)*, extraction *(c and d)*, and surgery *(e and f)*.

Efficiency

Precalculation of tooth movements can reduce the global treatment time by:

- Limiting the number of tooth movements to only those necessary by counteracting undesirable movements
- Eliminating dental arch leveling phases required in fixed orthodontic techniques
- Providing several treatment options via simulations that show methods with the shortest treatment time (Fig 1-9)

Disadvantages of the Invisalign System

Removability

The advantage of removability can become a disadvantage in the absence of patient compliance. Indeed, the patient must be vigilant in wearing an aligner every day for the requisite 22 hours a day and changing it every

other week without fail. In addition, intra- or interarch traction elastics may be prescribed, making removal and reinsertion of the aligner more complicated. Finally, removability increases the risk of loss or damage to the aligner, which can delay the progress of tooth movements.

Need for clinical experience

The clinician's knowledge of the system will improve with use; however, in order to become thoroughly familiar with the biomechanics of aligners and master the ClinCheck treatment simulation strategy, clinicians should initially perform only minor movements, such as closure of diastemas and correction of mild crowdings.

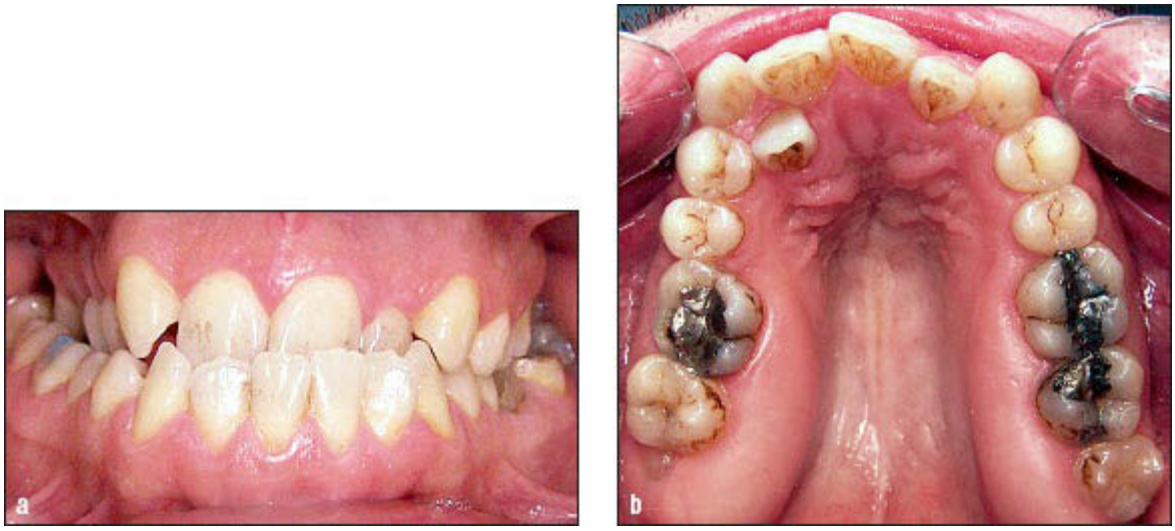


Fig 1-10 Frontal *(a)* and maxillary occlusal *(b)* views of a patient with a transverse deficiency.

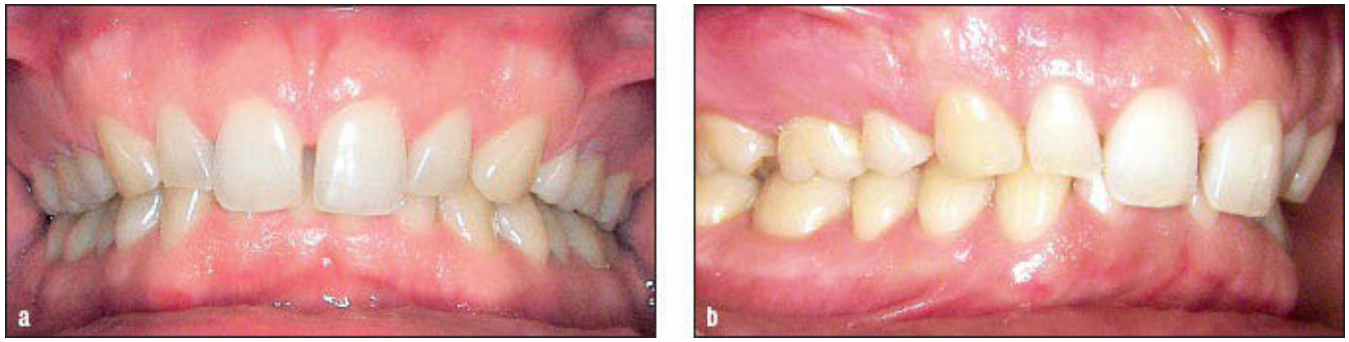


Fig 1-11 Frontal *(a)* and right lateral *(b)* views of a patient with a vertical deficiency.

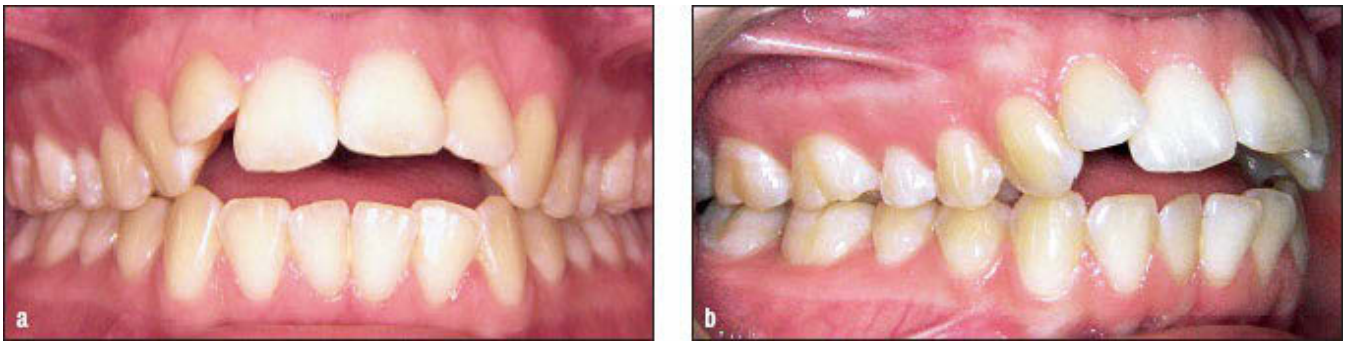


Fig 1-12 Frontal *(a)* and right lateral *(b)* views of a patient with a vertical excess.

Limitations in tooth movement capacity

Currently, there are some limitations in the range of tooth movement and other movements with the Invisalign system.

Skeletal corrections

Correction involving significant transverse expansion (Fig 1-10), vertical deficiency (Fig 1-11), distinct vertical excess (Fig 1-12), and pronounced sagittal discrepancies (Class II and Class III malocclusions) must be planned in conjunction with orthognathic surgery.

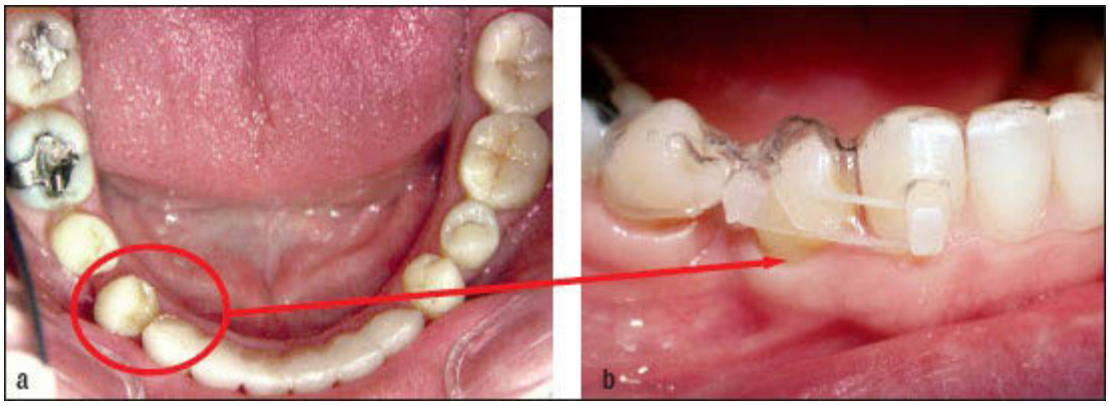


Fig 1-13 Premolars in rotation *(a)*, requiring an additional traction elastic on the aligner *(b)*.

Fig 1-14 *(a to c)* Saliva bubbles trapped within the aligner's inner surface as a result of poor teeth-aligner contact.

Dental corrections related to tooth morphology and position

- The aligner tends to slide around anatomically round teeth, such as mandibular second premolars.
- Teeth with significant intrusion or extrusion may require a combination of attachments, elastics (Fig 1-13), and/or mini-implants.
- Some tooth inclinations, such as mesial tipping, may prevent normal insertion of the aligner.

Interaction of teeth, saliva, and aligners

The esthetic advantages of Invisalign can be offset by saliva buildup. Saliva bubbles can form within the aligner's inner surface, between the appliance and teeth (Fig 1-14). This situation is usually the result of imperfect contact between the plastic and the tooth surface. Also, in some situations a discrepancy between the actual and anticipated tooth position, as projected by ClinCheck, can occur. The result is poor contact between teeth and aligner.

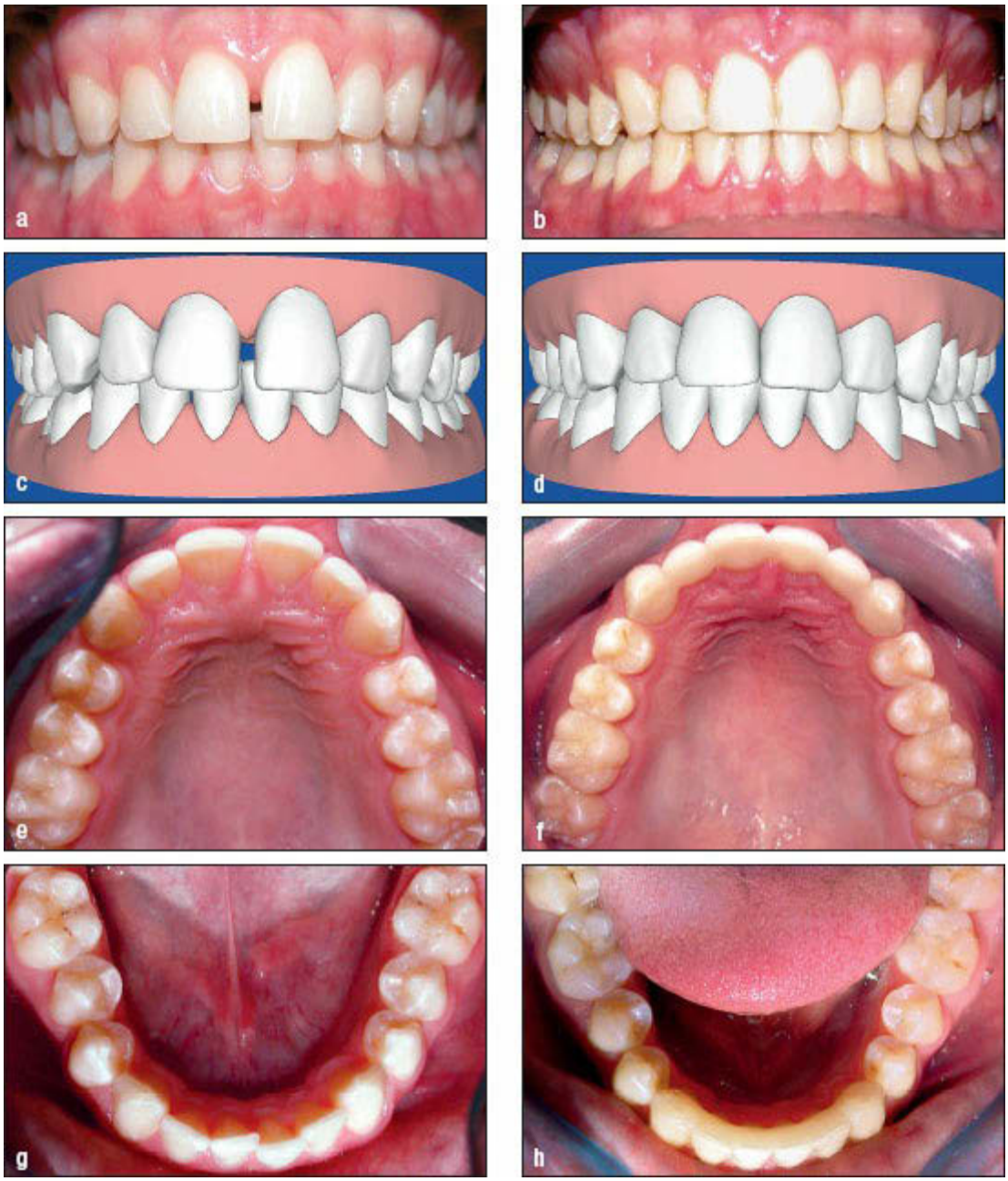


Fig 1-15 The patient presented with a diastema and mild spacing issues. Frontal view before *(a)* and after 6.5 months of treatment *(b)*. ClinCheck simulation of frontal view before *(c)* and after treatment *(d)*. Occlusal views before *(e and g)* and after 6.5 months of treatment *(f and h)*. Posttreatment retention was accomplished using fiber-reinforced splints (Ribbond-THM, Ribbond) or everStick (Stick Tech) bonded under rubber dam. (Retention by S. Gonthier).

Examples of Ideal Initial Invisalign Cases

Following are examples of cases that would be ideal for clinicians who are just starting out with Invisalign:

- Diastemas (Fig 1-15)
- Mild spacing or crowding (Fig 1-16)
- Unesthetic crowding (Fig 1-17)

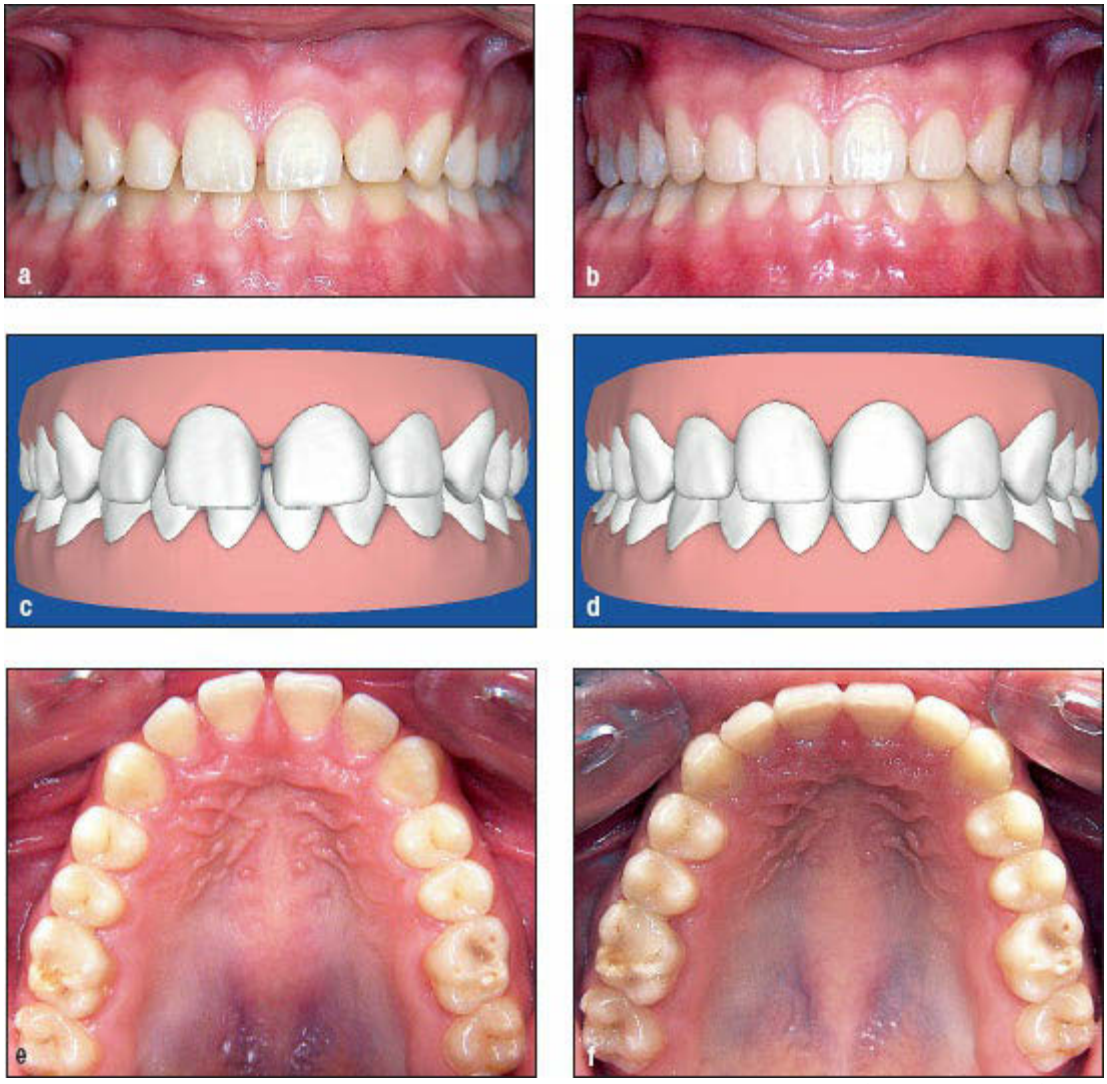


Fig 1-16 The patient presented with mild spacing issues. Frontal view before *(a)* and after 10 months of treatment *(b)*. ClinCheck simulation of frontal view before *(c)* and after treatment *(d)*. Maxillary occlusal views before *(e)* and after 10 months of treatment *(f)*.

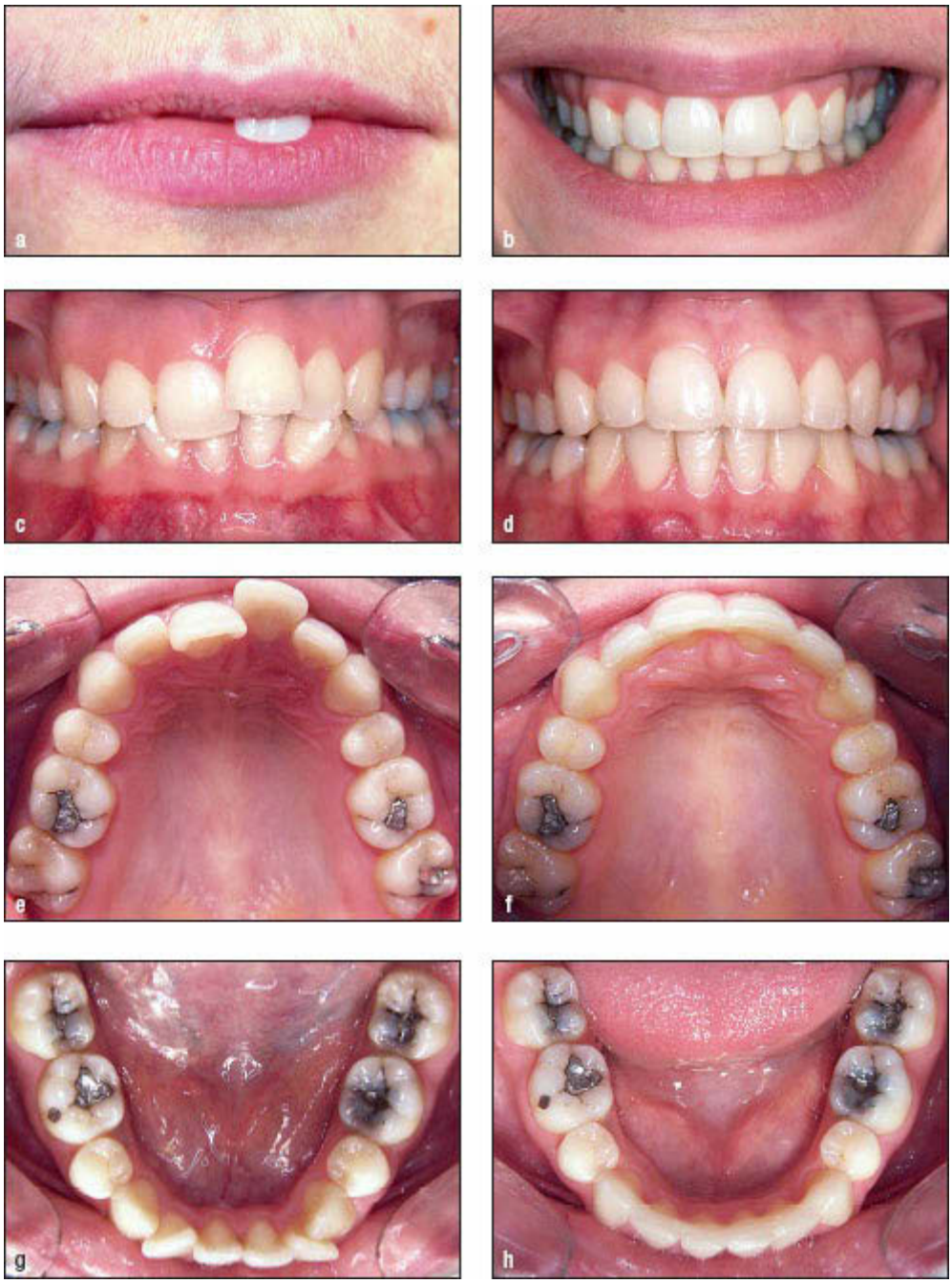


Fig 1-17 The patient presented with unesthetic crowding (relapse after treatment with fixed appliances). Frontal views before *(a and c)* and after 16 months of treatment *(b and d)*. Occlusal views before *(e and g)* and after 16 months of treatment *(f and h)*.

Invisalign Protocol

Overview of procedures

1. The clinician consults with the patient and performs diagnosis, treatment

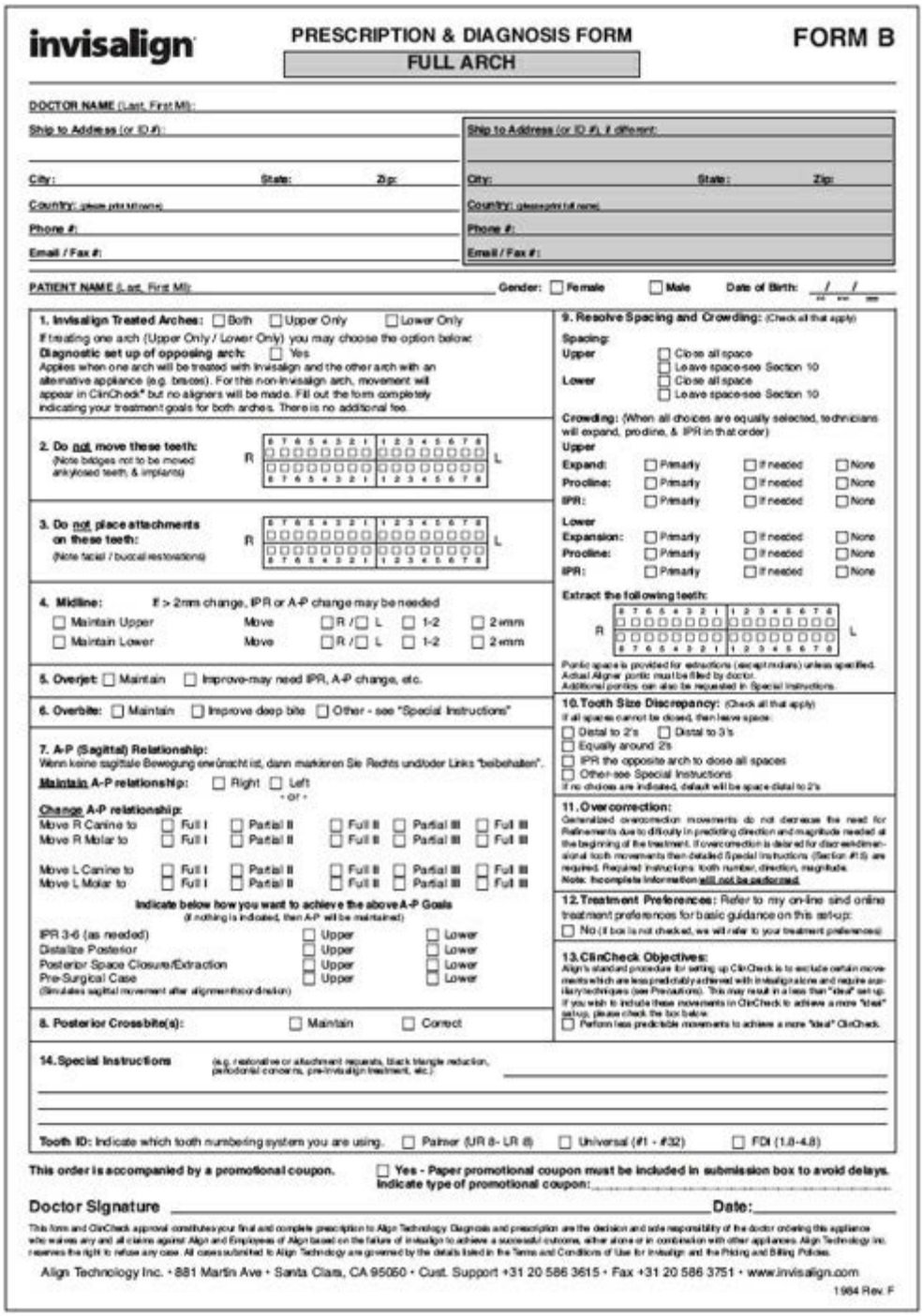
planning, and record-taking procedures.
2. From the clinician's diagnosis and treatment plan, Align Technology fabricates aligners based on the final computer graphic file (ClinCheck) validated by the clinician.
3. The patient receives the aligners and wears them until the end of treatment for desired results.

Step 1: Consultation

- During the first consultation, the clinician makes a diagnosis and identifies indications and contraindications associated with Invisalign treatment.
- During the second consultation, all the records necessary for Invisalign are made, eg, impressions, photographs, and radiographs. The patient's clinical records and treatment plan are submitted by mail or online via a password-protected interface called Virtual Invisalign Practice (VIP) to Santa Clara, California, for ClinCheck setup, which will be used later for fabrication of aligners.

Step 2: Fabrication of aligners

- Align Technology fabricates aligners from:
  —Accurate polyvinyl siloxane (PVS) impressions of dental arches and occlusion
  —Extraoral and intraoral photographs and dental and cranial radiographs
  —The treatment plan elaborated by the clinician (Fig 1-18)
- Align Technology creates a virtual model through computed tomography (Figs 1-19 and 1-20). Dentoalveolar units are individually cut and integrated into a working model after being digitally tailored in different colors (Fig 1-21). Tooth axes, positions, and contact points, as well as the gingival margin, are virtually specified and reproduced (Fig 1-22). The treatment plan is then applied, and the movements are performed in sequence via TREAT software (Performance Systems Development) (Fig 1-23).
- Align Technology creates a treatment simulation through CAD based on an animated 3D model (ie, ClinCheck). ClinCheck uses a digital video to show the movements of teeth from their initial to final positions.



invisalign

PRESCRIPTION & DIAGNOSIS FORM

FULL ARCH

FORM B

DOCTOR NAME (Last, First MI):

Ship to Address (or ID #):

City: State: Zip:

Country: (please print full name)

Phone #:

Email / Fax #:

Ship to Address (or ID #), if different:

City: State: Zip:

Country: (please print full name)

Phone #:

Email / Fax #:

PATIENT NAME (Last, First MI): Gender: ☐ Female ☐ Male Date of Birth: / /

1. Invisalign Treated Arches: ☐ Both ☐ Upper Only ☐ Lower Only

If treating one arch (Upper Only / Lower Only) you may choose the option below:

Diagnostic set up of opposing arch: ☐ Yes

Applies when one arch will be treated with Invisalign and the other arch with an alternative appliance (e.g. braces). For the non-Invisalign arch, movement will appear in ClinCheck® but no aligners will be made. Fill out the form completely indicating your treatment goals for both arches. There is no additional fee.

2. Do not move these teeth:
(Note bridges not to be moved, ankylosed teeth, & implants)

3. Do not place attachments on these teeth:
(Note facial / buccal restorations)

4. Midline: If > 2mm change, IPR or A-P change may be needed

☐ Maintain Upper Move ☐ R / ☐ L ☐ 1-2 ☐ 2 mm

☐ Maintain Lower Move ☐ R / ☐ L ☐ 1-2 ☐ 2 mm

5. Overjet: ☐ Maintain ☐ Improve-may need IPR, A-P change, etc.

6. Overbite: ☐ Maintain ☐ Improve deep bite ☐ Other - see "Special Instructions"

7. A-P (Sagittal) Relationship:
Wenn keine sagittale Bewegung erwünscht ist, dann markieren Sie Rechts und/oder Links "beibehalten".

Maintain A-P relationship: ☐ Right ☐ Left

- or -

Change A-P relationship:

Move R Canine to	☐ Full I	☐ Partial II	☐ Full II	☐ Partial III	☐ Full III	
Move R Molar to	☐ Full I	☐ Partial II	☐ Full II	☐ Partial III	☐ Full III	
Move L Canine to	☐ Full I	☐ Partial II	☐ Full II	☐ Partial III	☐ Full III	
Move L Molar to	☐ Full I	☐ Partial II	☐ Full II	☐ Partial III	☐ Full III	

Indicate below how you want to achieve the above A-P Goals
(If nothing is indicated, then A-P will be maintained)

IPR 3-6 (as needed)	☐ Upper	☐ Lower
Distalize Posterior	☐ Upper	☐ Lower
Posterior Space Closure/Extraction	☐ Upper	☐ Lower
Pre-Surgical Case (Simulates sagittal movement after alignment/coordination)	☐ Upper	☐ Lower

8. Posterior Crossbite(s): ☐ Maintain ☐ Correct

9. Resolve Spacing and Crowding: (Check all that apply)

Spacing:

Upper
- ☐ Close all space
- ☐ Leave space-see Section 10

Lower
- ☐ Close all space
- ☐ Leave space-see Section 10

Crowding: (When all choices are equally selected, technicians will expand, proclineand IPR in that order)

Upper			
Expand:	☐ Primarily	☐ If needed	☐ None
Procline:	☐ Primarily	☐ If needed	☐ None
IPR:	☐ Primarily	☐ If needed	☐ None
Lower			
Expansion:	☐ Primarily	☐ If needed	☐ None
Procline:	☐ Primarily	☐ If needed	☐ None
IPR:	☐ Primarily	☐ If needed	☐ None

Extract the following teeth:

Points space is provided for extractions (except molars) unless specified. Actual Aligner points must be filled by doctor. Additional points can also be requested in Special Instructions.

10. Tooth Size Discrepancy: (Check all that apply)
If all spaces cannot be closed, then leave space:
- ☐ Distal to 2's ☐ Distal to 3's
- ☐ Equally around 2's
- ☐ IPR the opposite arch to close all spaces
- ☐ Other-see Special Instructions

If no choices are indicated, default will be space distal to 2's

11. Overcorrection:
Generalized overcorrection movements do not decrease the need for Refinements due to difficulty in predicting direction and magnitude needed at the beginning of the treatment. If overcorrection is desired for discrete/dimensional tooth movements then detailed Special Instructions (Section #14) are required. Required instructions: tooth number, direction, magnitude.
Note: Incomplete information will not be performed.

12. Treatment Preferences: Refer to my on-line and online treatment preferences for basic guidance on this set-up:
☐ No (If box is not checked, we will refer to your treatment preferences)

13. ClinCheck Objectives:
Align's standard procedure for setting up ClinCheck is to exclude certain movements which are less predictably achieved with Invisalign alone and require auxiliary techniques (see Precautions). This may result in a less than "ideal" set-up. If you wish to include these movements in ClinCheck to achieve a more "ideal" setup, please check the box below:
☐ Perform less predictable movements to achieve a more "ideal" ClinCheck.

14. Special Instructions (e.g. rotations or attachment requests, black triangle reduction, periodontal concerns, pre-Invisalign treatment, etc.)

Tooth ID: Indicate which tooth numbering system you are using. ☐ Palmer (UR 8- UL 8) ☐ Universal (#1 - #32) ☐ FDI (1.8-4.8)

This order is accompanied by a promotional coupon. ☐ Yes - Paper promotional coupon must be included in submission box to avoid delays.
Indicate type of promotional coupon:

Doctor Signature Date:

This form and ClinCheck approval constitutes your final and complete prescription to Align Technology. Diagnosis and prescription are the decision and sole responsibility of the doctor ordering this appliance who waives any and all claims against Align and Employees of Align based on the failure of Invisalign to achieve a successful outcome, either alone or in combination with other appliances. Align Technology Inc. reserves the right to refuse any case. All cases submitted to Align Technology are governed by the details listed in the Terms and Conditions of Use for Invisalign and the Pricing and Billing Policies.

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1984 Rev. F

Fig 1-18 Comprehensive treatment planning form.

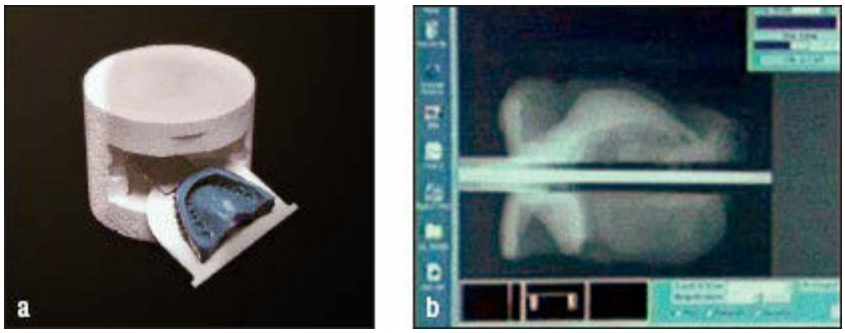


Fig 1-19 *(a and b)* From the reading of the patient's impressions, a virtual model is created by computed tomography.

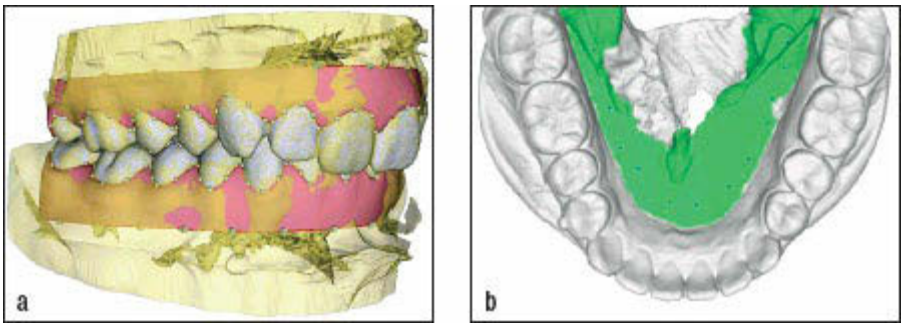


Fig 1-20 *(a and b)* Scanned images of the impression.

Fig 1-21 *(a)* Individualization of dentoalveolar units (Tooth Shaper software). *(b)* Teeth are colored in order to be distinguished from one another. *(c)* Each tooth is segmented.

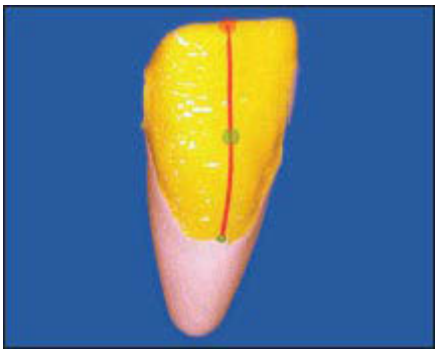


Fig 1-22 The axis of the clinical crown is represented through three-point registration. ClinCheck now uses six-point registration as well to calculate the extent of crown displacement (see Fig 5-21n).

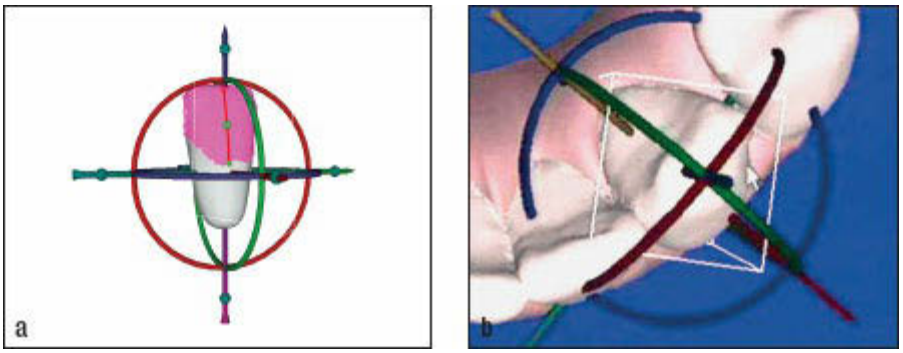


Fig 1-23 *(a and b)* Teeth are moved to correct their position in all axes.

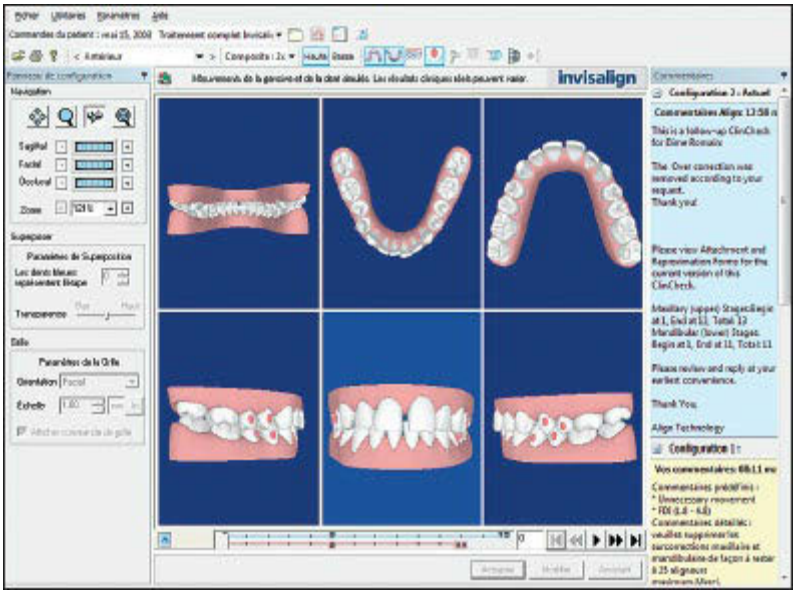


Fig 1-24 Simulated movements of gingiva and teeth in ClinCheck.

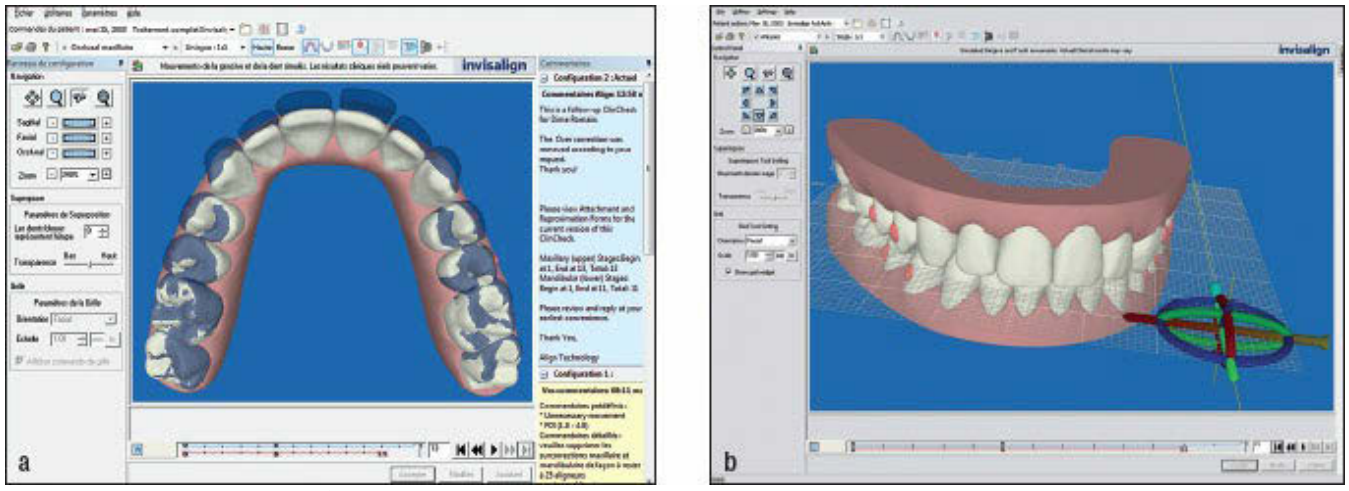


Fig 1-25 Simulated movements. Control tools: superimpose *(a)* and grid *(b)*.

- The clinician receives the initial 3D treatment simulation generated by ClinCheck. The correspondence between virtual and real clinical

conditions, from all perspectives, can be verified through the animated setup (Fig 1-24). There are control tools (eg, zoom, grids, and superimpose) that the clinician can use to assess the simulated movements with regard to clinical reality. Number, type, and position of attachments; amount and staging of interproximal reductions; and measurement of teeth or their movements can be verified and controlled (Fig 1-25). The treatment plan proposed by ClinCheck can be modified, or new treatment plans can be requested online until one is satisfactory.

- Align Technology fabricates a series of thermoformed medical PVS overlays (ie, aligners) to be used for treatment.

Step 3: Treatment

Each in the series of aligners is worn in 2-week increments (22 hours a day for 14 days, over 300 hours of aligner wear) until the desired result is achieved.

Biomechanics of Orthodontic Aligners

2

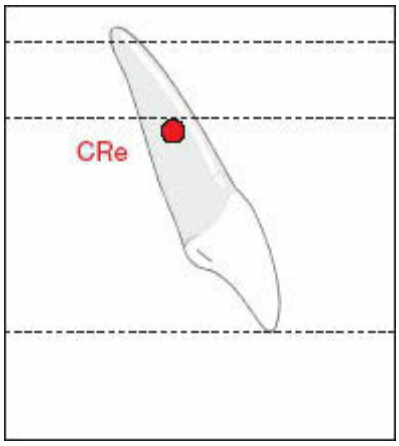


Fig 2-1 Illustration of CRe on an incisor.

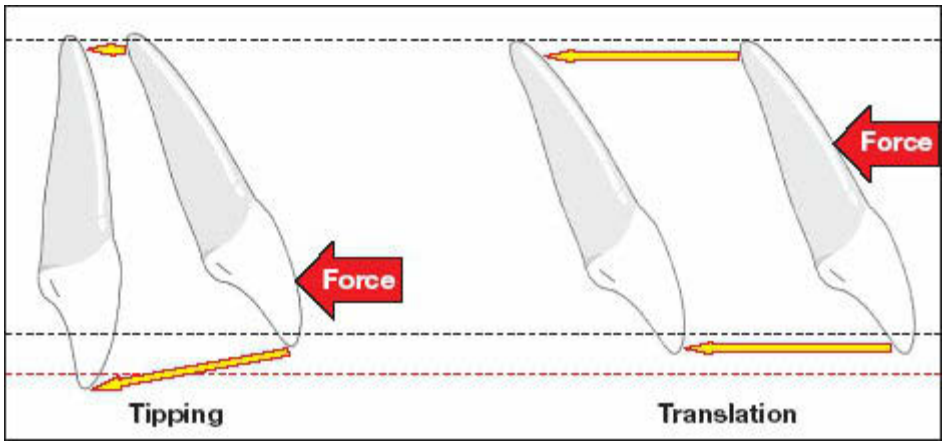


Fig 2-2 Tipping *(left)* and translation (bodily movement) *(right)*.

Applications of Force in Orthodontics

Center of resistance

Teeth are attached to alveolar bone by the periodontal ligament, which resists any external force. When force is applied, teeth and the surrounding tissues (ligament, bones, blood vessels, etc) react in their own characteristic fashion. The location of the center of resistance (CRe) depends on the substance and the environment but is independent of the force system. In the mouth, the CRe is generally situated at the apical third of the root in a healthy tooth without attachment loss (Fig 2-1). Application of a force in this area causes pure bodily movement, also known as *translation* (Fig 2-2).

Center of rotation

To control movement of a tooth requires an understanding of its CRe as well as its center of rotation (CRo), which refers to the center of resistance modified by the applied force system. The relationship between these two centers also influences tooth movement: the closer the CRo is to the CRe, the more the tooth movement will aim toward tipping; the farther the two centers are apart, the more the tooth movement will aim toward translation (see Fig 2-2).

Anchorage

In orthodontic biomechanics, *anchorage* is defined as resistance to unwanted movement. A body will move only when the forces driving the movement overcome the forces of resistance (or fixed resistance). The strength of tooth anchorage depends on the tooth root surface area (and the number of teeth included in the anchorage). An incisor with a single root has less anchorage than a molar with two or three roots. Anchorage also may be increased with the use of appliances such as transpalatal arches, lip bumpers, extraoral devices, and mini-implants.

The forces required for tooth movement have been established.[1] Optimal forces allow good oxygenation of tissues and stimulation of bone cellular activity without occluding blood vessels in the periodontal ligament. Damon[2] has described a zone of applied forces with sufficient intensity to direct tooth movement toward bone reorganization, known as the biozone. This movement is controlled by osteoblasts that are stimulated by continuous oxygenation of the periodontium. However, if the forces applied to the fragile and vascularized structure of the periodontal ligament are too strong, the capillaries running on the surface and into the alveolar bone can become compressed. A reactionary inflammatory phenomenon then provokes osteoclast activity that destroys the alveolar bone and promotes root resorption. Some authors therefore advocate the use of light forces to optimize tooth movement. There is further disagreement between authors who favor the use of intermittent forces and authors who prefer continuous and progressive forces. Damon[2] proposes the “low force, low friction” system, and Soulie et al[3] recommend a reduced load-deflection ratio by using superelastic copper nickel-titanium wires to allow appropriate three-dimensional control of tooth movement rather than using reduced cross-section wires.

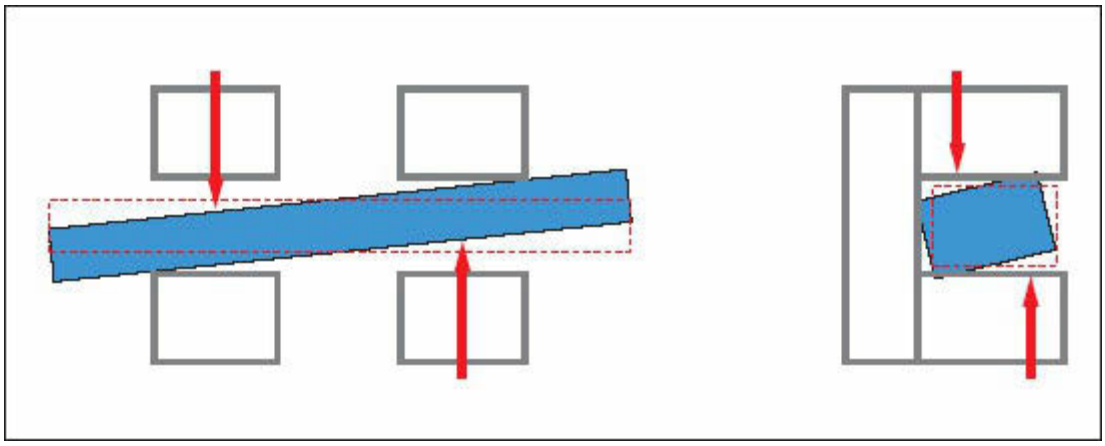


Fig 2-3 Loss of force transmission with use of bracket and wire.

Advantages of Aligners

Force application

When a new aligner is inserted into the mouth, an almost continuous force (22 hours a day) will build and then rapidly decrease, allowing a long period of tissue rest that is favorable for reorganization of the periodontium. In addition, since the aligner must be removed for the approximately 2 hours a day devoted to eating and drinking and oral hygiene procedures, the application of intermittent forces helps avoid cellular resistance.[4] Furthermore, these forces are primarily applied only to move specific teeth (through the aid of ClinCheck), while other teeth serve as anchorage. The risk of damage to dental and periodontal tissues is thereby limited. Fixed resistance is established by the unmoved teeth while there is movement of only certain teeth. These characteristics make Invisalign biomechanically suitable for cases with controlled severe attachment loss and for mixed dentitions in which the presence of the roots of primary teeth must be protected so as to allow for the agenesis of permanent teeth.

Force transmission and direction between appliance and teeth

Interface

Orthodontic wire is usually too small in relation to corresponding brackets,

which leads to a significant loss of force transmission of three orders (Fig 2-3):

- First order, horizontal direction
- Second order, vertical direction
- Third order, buccolingual direction (torque control)

Fig 2-4 *(a to c)* An aligner covers and molds over all available tooth surfaces to transmit the best therapeutic force.

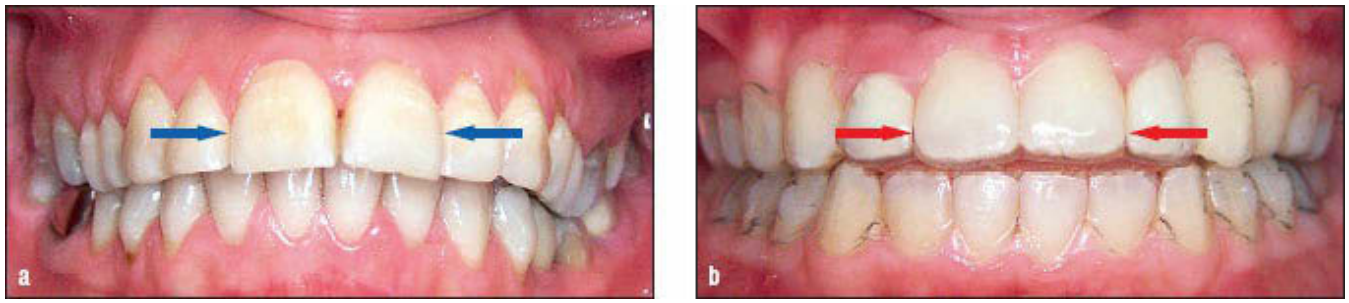


Fig 2-5 Photos of teeth without *(a)* and with *(b)* a maxillary aligner, showing how the perfect contact between teeth and appliance allows transmission of gentle, targeted, and programmable force.

Bracket position can be influenced by tooth anatomy, the skill of the clinician, and the amount of bonding agent used.

A custom-molded aligner with intimate contact between the internal surface and the tooth crowns will transmit the totality of force to teeth in three orders from the very first stage of treatment (Figs 2-4 and 2-5).

In contrast to brackets, the position of the aligner is not influenced by tooth anatomy. Moreover, an aligner can be placed directly over prostheses, reconstructions, and malformed teeth such as peg-shaped lateral incisors (Fig 2-6).

Friction

Tooth movement produces friction between the orthodontic wire and the bracket. For this reason, stages of leveling and decompensation of the

dental arches are necessary during fixed orthodontic therapy. The level of friction will depend on:

- Bracket finish and shape, particularly the inner surface ridges.
- Wire composition. Less friction occurs in stainless steel alloy than nickel-titanium wires and in large cross-section than small cross-section wires.
- Ligature. Self-ligating brackets produce 2.5 times less friction than metal ligatures, although metal ligatures are superior to elastomeric ligatures.
- Tooth malposition, which determines the amount of wire deformation.

Force must be increased to counter friction and control the ratio of force to moment.

Fig 2-6 Esthetic preprosthetic orthodontic treatment. A young woman presented with maxillary peg-shaped lateral incisors, an impacted canine, and anterior spacing requiring esthetic preprosthetic and preimplant orthodontic treatment using aligners. Before treatment *(a, c, and e)*. After treatment with aligners and prostheses *(b, d, and f)*.

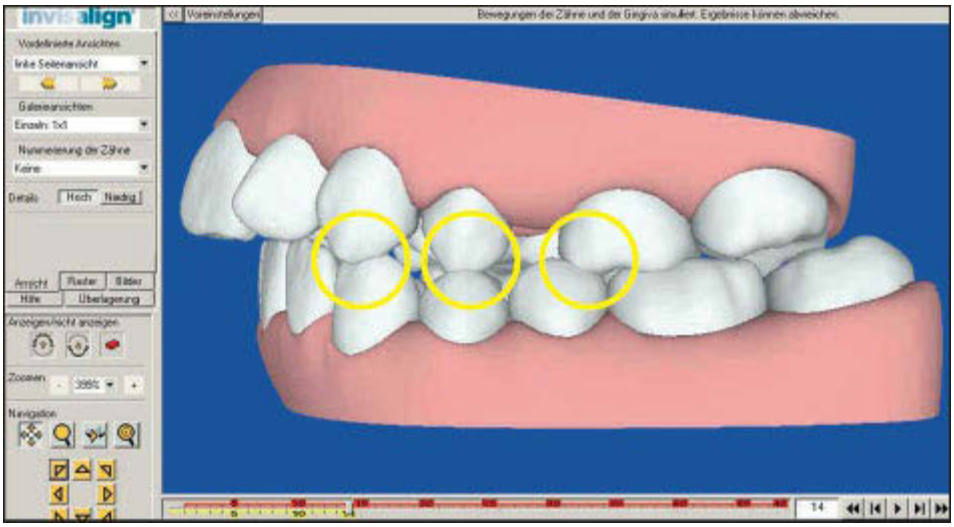


Fig 2-7 Management of interarch collisions by TREAT software (Performance Systems Development).

It is important to remember that occlusal interferences during orthodontic moment can lead to interdental friction, which provokes undesirable anchorage loss because of abnormal interdental contacts. Treatment with aligners limits this potential for increased friction by eliminating bracket, wire, and ligature interactions. Because an aligner envelops the dental arches, it reduces the influence of pressure from surrounding muscles and occlusion. The pressure is better distributed, and interarch dental trauma is significantly decreased (Fig 2-7).

In addition, decreased force application to teeth limits periodontal and bone proprioception below a critical threshold and avoids alveolar bone destruction while encouraging osteoblastic bone restructuring.

Invisalign Treatment in a High-Risk Periodontal Case

The patient was diagnosed with rapidly progressive periodontitis with 40% to 70% generalized attachment loss combined with occlusal problems and a high risk of relapse after treatment (Figs 2-8a and 2-8b). After 10 months of periodontal treatment (performed by J. Charon), no increased tooth mobility was observed. The spacing between the left central and lateral incisors was spontaneously reduced (Fig 2-8c). Invisalign treatment was carried out (Figs 2-8d and 2-8e).

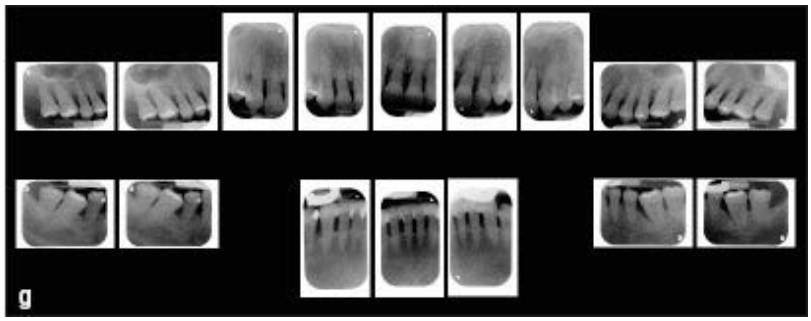
Following Invisalign treatment, no periodontal disease was detected. The radiologic assessment clearly showed radiologic improvements

corresponding to a consolidation but not regeneration of mineralized tissues (Figs 2-8f and 2-8g). The patient's oral health and esthetics were significantly improved by the combination of periodontal therapy and Invisalign treatment (Figs 2-8h and 2-8i).

Figs 2-8a and 2-8b Frontal view *(a)* and periapical radiographic assessment *(b)* at the initial consultation. (Courtesy of J. Charon.)

Fig 2-8c After 10 months of periodontal therapy.


Figs 2-8d and 2-8e Invisalign treatment stage 7/60 on the maxilla and 7/44 on the mandible.

Figs 2-8f and 2-8g Frontal view *(f)* and periapical radiographic assessment *(g)* following Invisalign treatment.


Figs 2-8h and 2-8i Maxillary occlusal views before *(h)* and after *(i)* treatment.

References

1. Nourry B. The Damon system. Int Orthod 2006;4:369–386.
2. Damon DH. The rationale, evolution and clinical application of the self-ligating bracket. Clin Orthod Res 1998;1:52–61.
3. Soulie P-J, Le Gall M, Volpi J, Morgan G. Contrôle de l'incisive supérieure en technique de glissement optimize. Int Orthod 2006;4:443–454.

4. Davidovitch Z. Le déplacement dentaire. Rev Orthop Dento Fac 1994;30:42–53.

Clinical Records

3

Fig 3-1 Materials for impression taking, as well as those recommended for intraoral photography (see following section).

Impression-Taking Procedures

Materials

Materials and instruments for impression-taking procedures must be organized in advance (Fig 3-1). Following are the materials required:

- Invisalign impression tray, knife, towels, cup, timer
- High-viscosity silicone
- Low-viscosity silicone
- Bite registration silicone

It is also helpful to have cleansing towelettes prepared to remove any silicone from the patient's face. In addition, Virtual Invisalign Practice (VIP) should be on-screen on a nearby computer to allow completion of the patient's prescription chart during silicone polymerization.

Considerations for successful impression taking

Blocking out spaces with wax

Following polymerization, to avoid any risk of silicone tear upon removal of the impression tray from the mouth, interdental spaces, including those incorporated in a fixed partial denture, must be blocked out with wax or an equivalent material. This practice is especially important in patients with periodontal attachment loss (Fig 3-2). Respecting the tooth morphology avoids problems with excess wax.

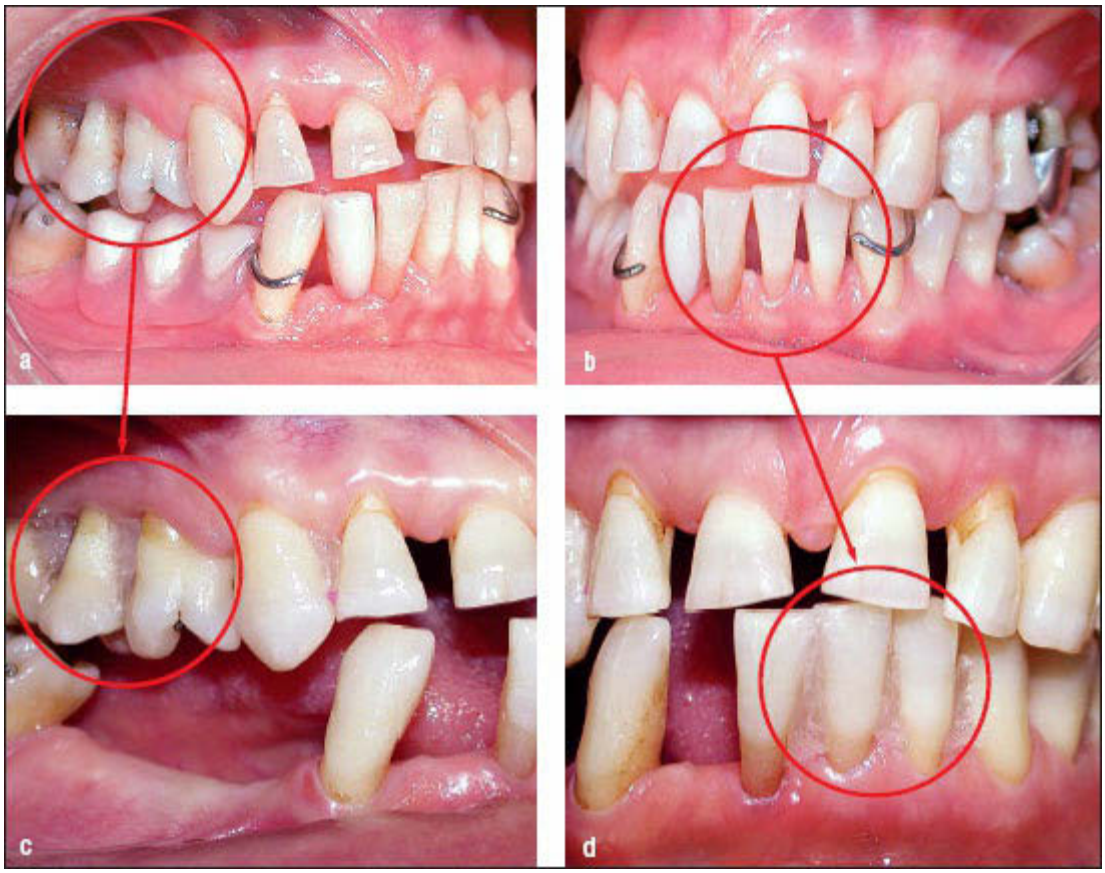


Fig 3-2 In the presence of severe periodontitis *(a and b)*, the dental arches must be prepared for impression taking by blocking out all spaces with wax *(c and d)* to avoid tearing the silicone.

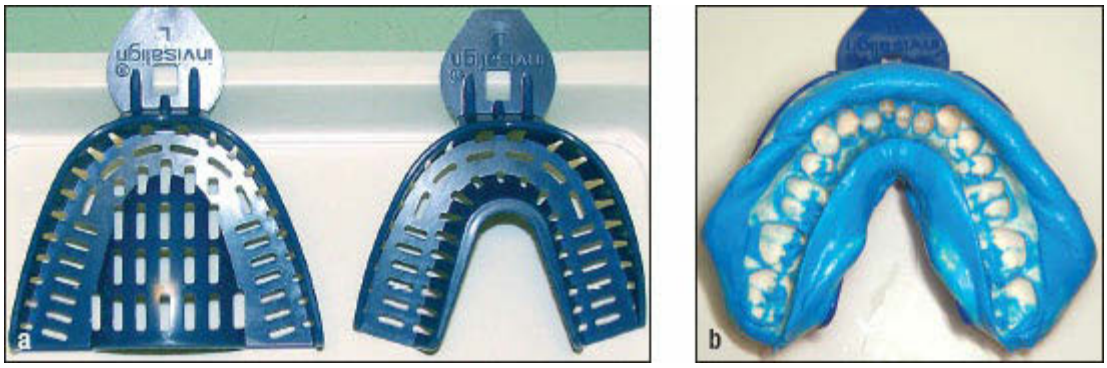


Fig 3-3 *(a)* Invisalign impression trays. *(b)* Fabricated in thermoformable plastic, they can be adjusted precisely before material is loaded.

Use of appropriate impression trays

Thermoformable blue plastic perforated trays are supplied by Invisalign in four different sizes: small, medium, large, and extra-large (Fig 3-3).

Oral impressions are taken with alginate and poured with hard plaster. The resulting models are then used to make individual impression trays by adapting an Invisalign impression tray previously warmed in boiling water.

Another method for fabricating an individual impression tray is taking an impression of the plaster model with an impression tray filled with high-viscosity silicone (putty). A plastic film is placed on the model to create a space to prevent deformation of the low-viscosity silicone when it is later loaded on heavy silicone at the time of impression taking in the mouth (Fig 3-4).

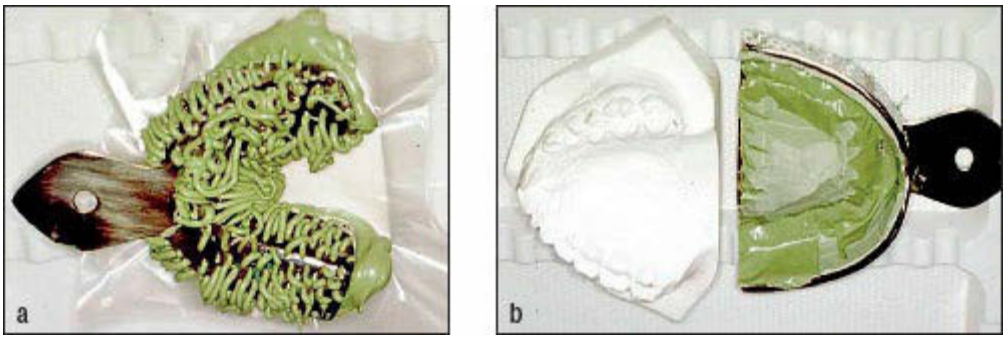


Fig 3-4 *(a)* Impression taking of a model covered with a plastic separating sheet. *(b)* Light-body silicone is then loaded on the heavy-body silicone for impression taking in the mouth.

Since computer simulation and fabrication of aligners will be conceived from these impressions, it is extremely important to obtain high-quality impressions. Poor impressions will result in poor adaptation of aligners on teeth, interfering with planned tooth movements and esthetics (See Figs 1-14a to 1-14c).

Avoiding defects

Align Technology will refuse any impression presenting defects beyond small details that can be digitally eliminated (Fig 3-5).

Common defects to be eliminated include (Fig 3-6):

- Insufficient impression material.
- Pulled away silicone due to poor insertion of impression tray or shifted polymerization of heavy- and light-body polyvinyl siloxane (PVS).
- Bubbles or voids. These will decrease the quality of contact between aligner and teeth; therefore, a new impression should be taken.

In most cases, a PVS setting time of 6 minutes must be respected. High-viscosity material should be well loaded at the retromolar area of the impression tray to avoid displacement of the material in the distal area.

Shipping

Once impressions are successfully obtained, they must be carefully protected using the Invisalign packaging materials before being shipped to Align Technology. Each Invisalign shipping box contains a shipping form as well as three small bags with protective plastic bubbles for maxillary and mandibular impressions and a bite registration (Fig 3-7). A checklist is also enclosed.

If radiographs, photographs, and the treatment plan cannot be submitted online, they can be sent with the impressions.

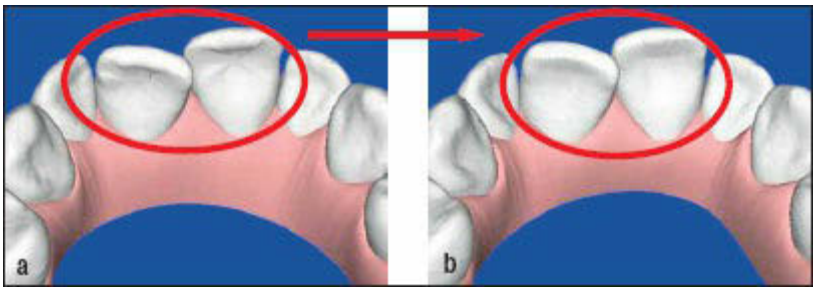


Fig 3-5 Small imperfections in an impression *(a)* can be digitally corrected *(b)*.

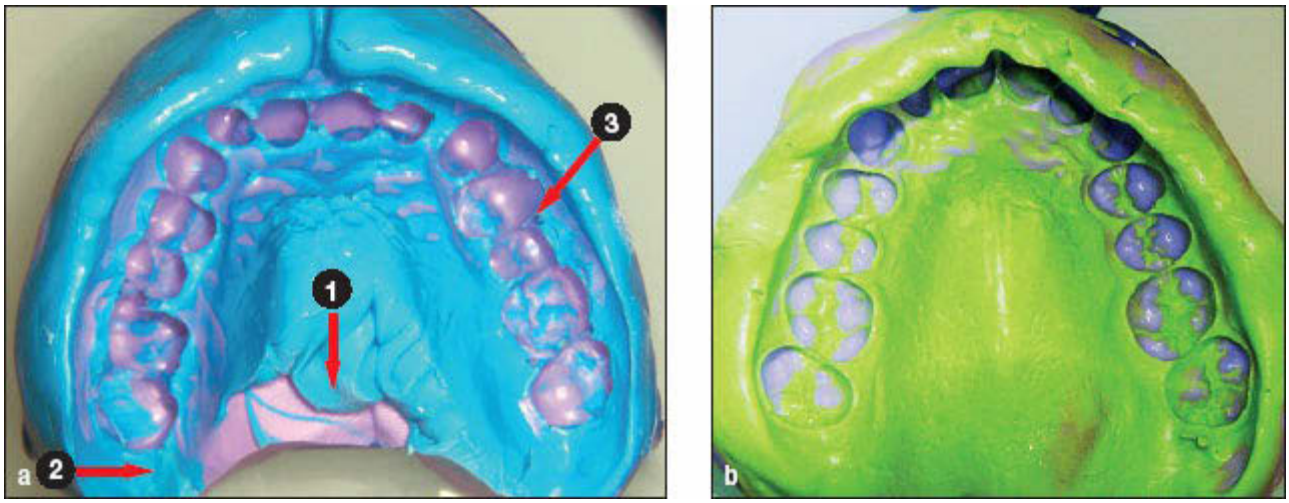


Fig 3-6 *(a)* Common defects that should be eliminated from an impression: 1, insufficient impression material; 2, pulling away of impression material; 3, bubbles or voids. *(b)* Impression without defects.

Fig 3-7 Invisalign packaging assures protection of the impressions during shipment. *(left to right)* Maxillary impression, bite registration, and mandibular impression.

Photographs

Extraoral and intraoral photographs are needed. Taking photographs with a digital camera is recommended to assure image reproduction quality and allow for retouching. Images must conform to the alignment standards indicated by Invisalign, ie, images of the face should be aligned on the Frankfort horizontal plane, and images of teeth should be aligned on the horizontal occlusal plane.

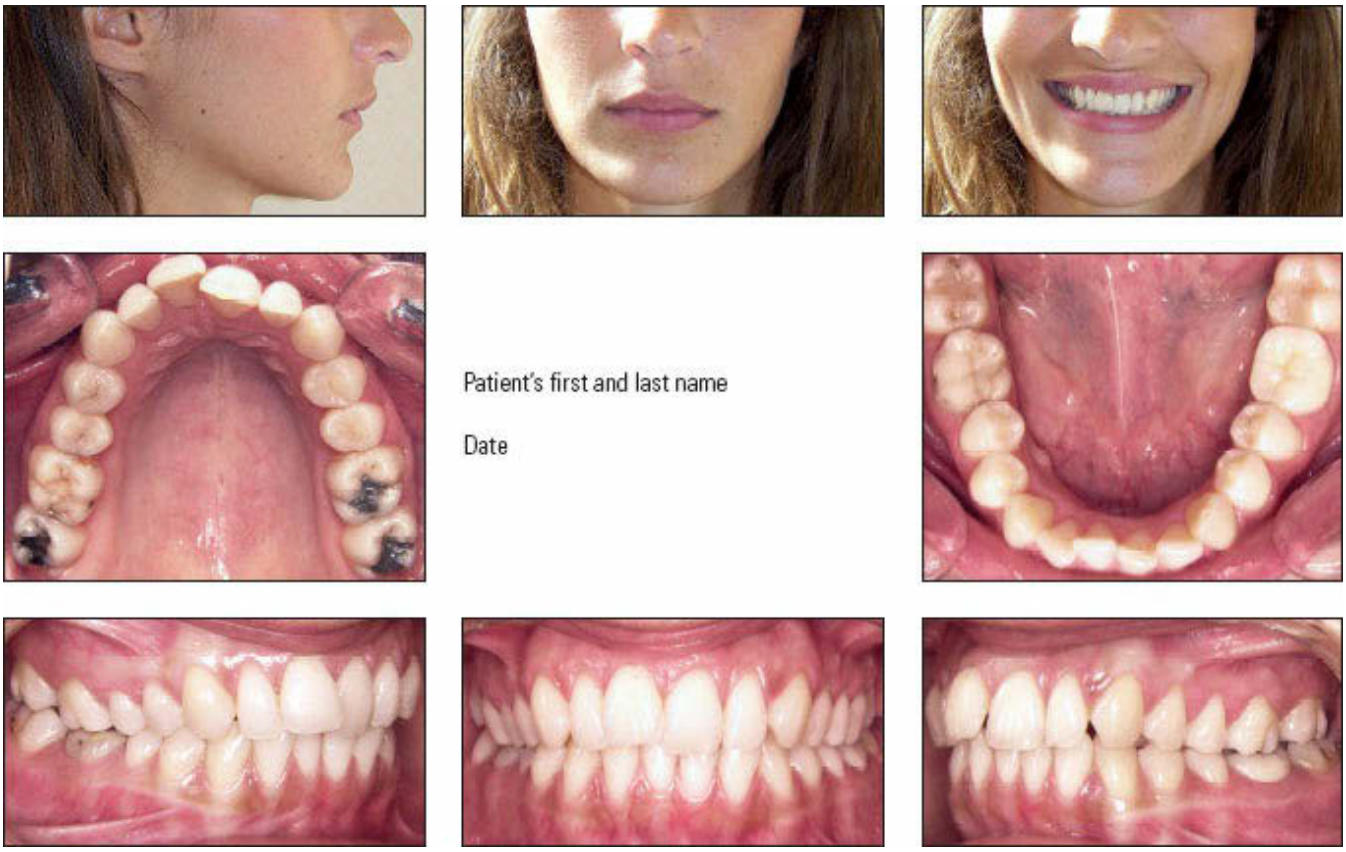


Fig 3-8a Photographs in composite layout.

Materials and devices

- Digital camera with dental flash and close-up lens
- Image retouching software
- Photography tray with retractor, occlusal mirror, dental mirror, and articulating paper (200 µm thick) (see Fig 3-1)

Articulating paper is used to mark intercuspal contact points, thus allowing Align Technology technicians to place scanned maxillary and mandibular impressions precisely in occlusal position.

The photographs are sent as individual or composite photos using VIP during online submission of the treatment plan.

Composite format

- Reduce the photo size with image management software to 640 × 480 pixels to facilitate rapid uploading and access.
- In Windows XP, composite photos can be created with Microsoft Office

PowerPoint, which will automatically reduce the size of photos and then save the file in JPG format.

- With Windows Vista, Kodak Dental Photographic Template (the software developed by Kodak for Invisalign) can be used. The clinician's data are stored, and a composite photo is automatically generated from the patient's individual photos.
- The composite layout includes extraoral and intraoral photographs placed in order as directed on the VIP website (Fig 3-8):
  —Row 1: Extraoral right profile repose, frontal repose, and frontal smiling
  —Row 2: Intraoral maxillary occlusal, patient's name and date, and intraoral mandibular occlusal
  —Row 3: Intraoral right buccal, anterior, and left buccal

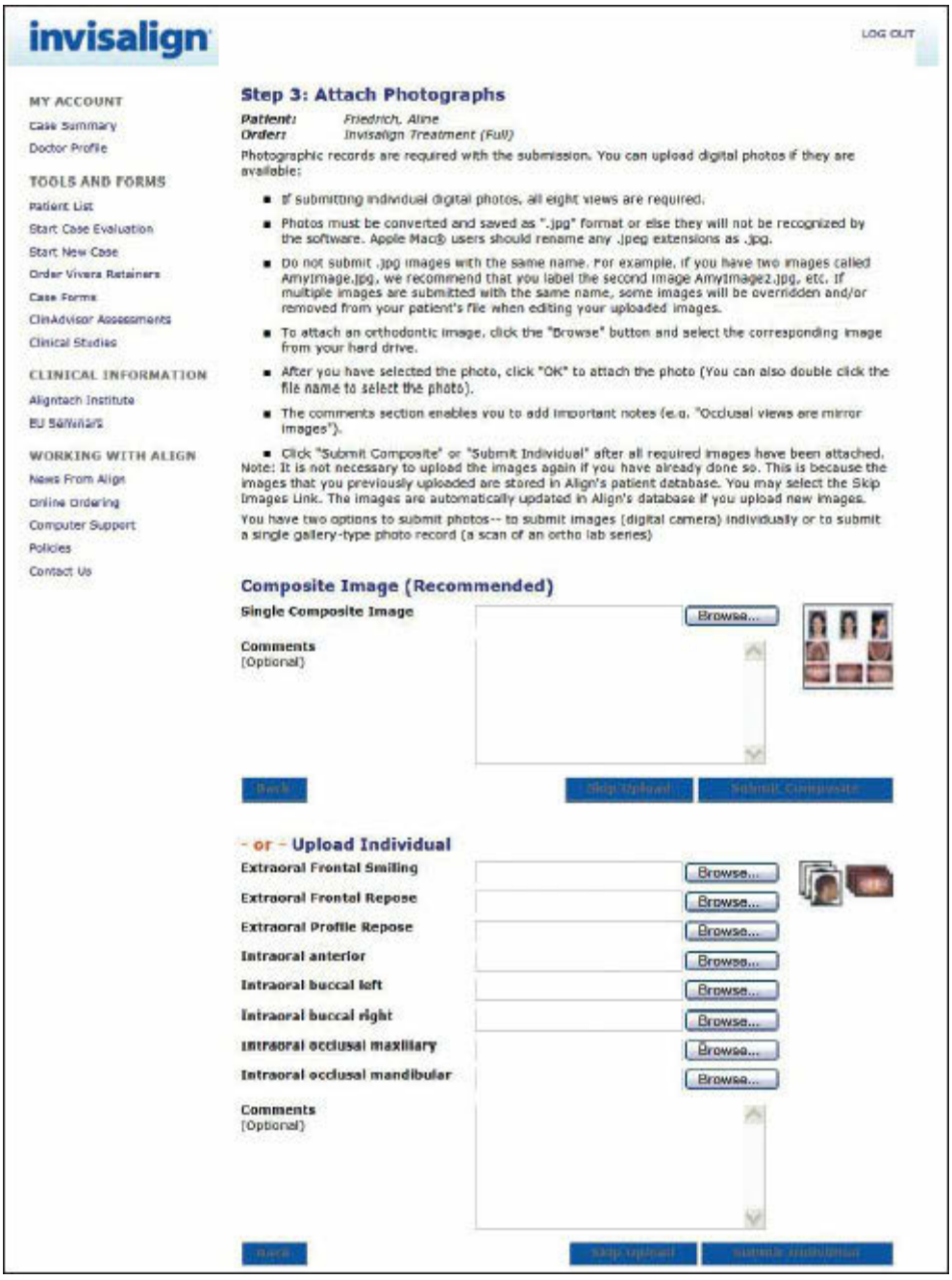


Fig 3-8b Uploading photographs via VIP.

Additional photographic tips

- Photographs of the maxillary and mandibular arches marked with thin articulating paper to indicate intercuspal contact areas during recorded and/or desired occlusal position can be sent to facilitate the repositioning of the arches in occlusion by Align technicians.
- Individual photos should be submitted following the uploading order given in VIP. It is thus preferable to initially save the image files with the names

that will ultimately be used to upload them.

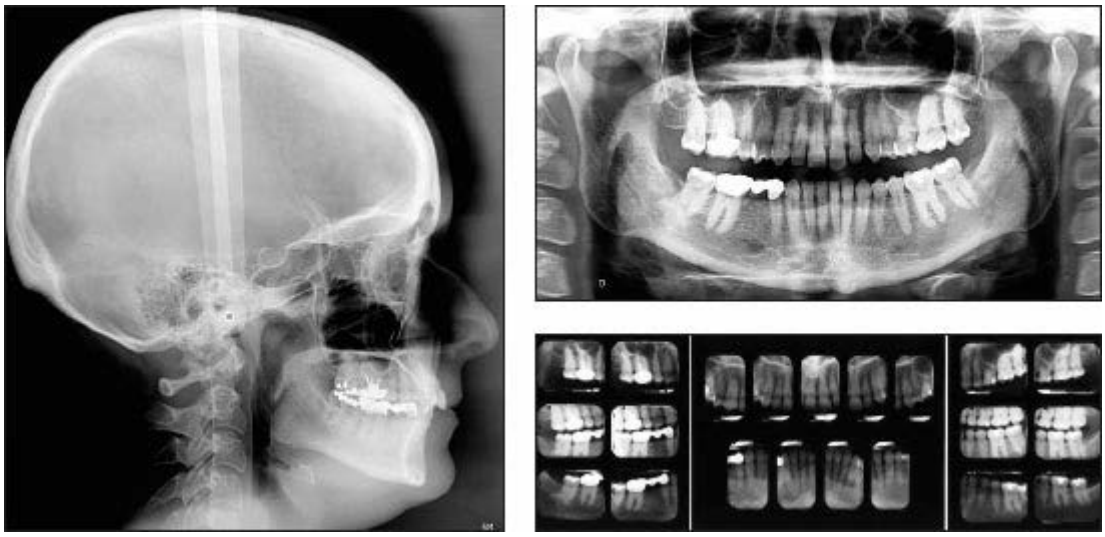


Fig 3-9a Radiographic assessment

Radiographs

Radiographic records of the skull and teeth are not required but are highly recommended for setting up ClinCheck (Fig 3-9).

They include:

- A lateral cephalometric radiograph
- A dental panoramic radiograph
- Parallel periapical radiographs

Successful radiographs

Film

Film radiographs are now obsolete. If they are used, they must be shipped to Align Technology unless the radiologist can provide a copy of the images on a CD. Original images can then be preserved and digital images used for online submission. Another option would be to take a photograph of the radiographs on a lighted film viewer with a digital camera without flash, then submit the photographs online.

Digital

Most current radiography devices are digital, which facilitates image treatment and retouching. Online submission can be immediately performed using VIP when the dental clinic is equipped with a digital radiography machine.

Important Clinical Points

- The quality of ClinCheck will depend on that of the clinical, photographic, and radiographic records, so be sure to provide high-quality, properly formatted records.
- To streamline the record-taking process, treatment plan prescription and submission of photographs and radiographs (providing that these images have already been properly framed and sized) can be done online at the time of impression taking, while the silicone sets (6 minutes for each arch).

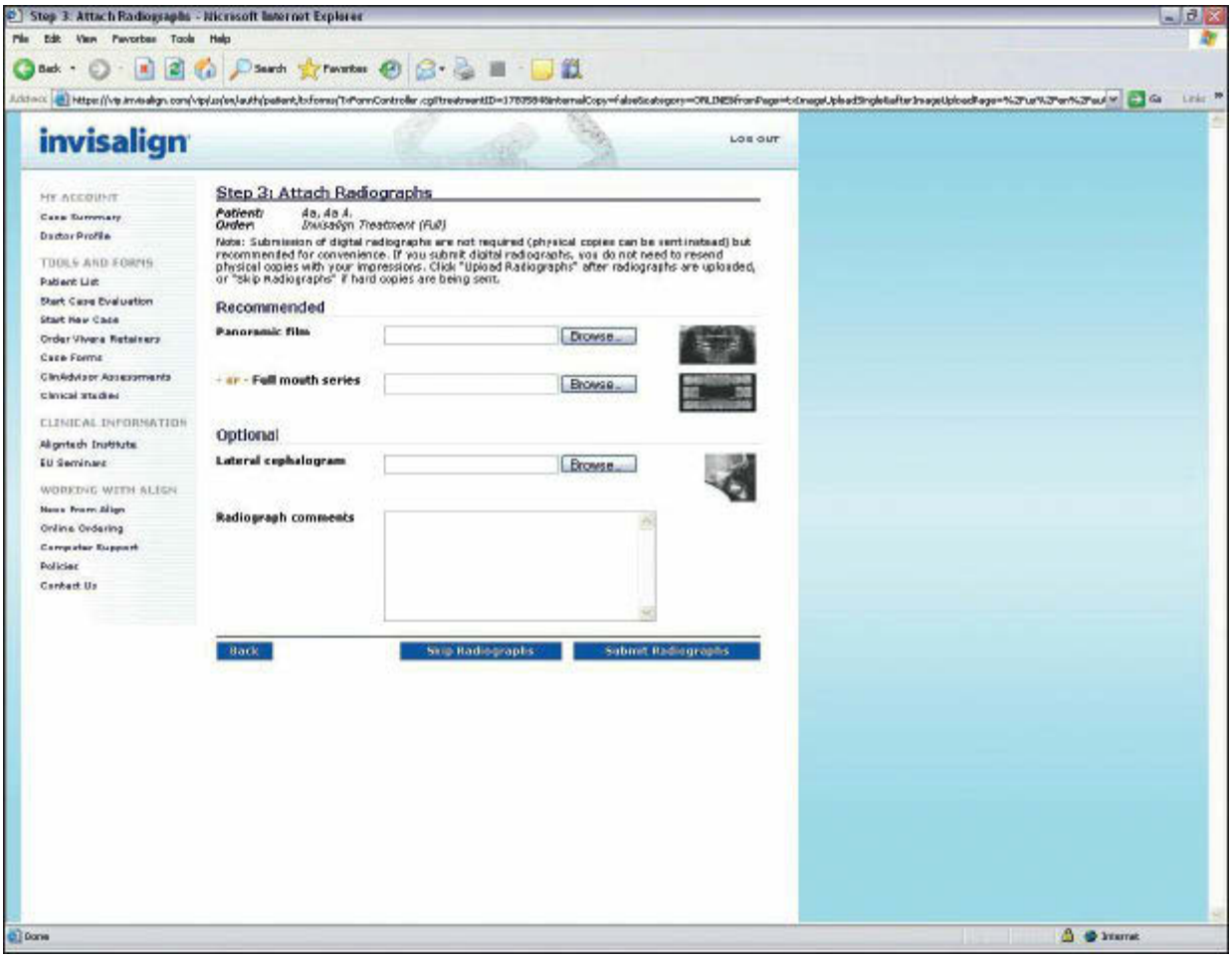


Fig 3-9b Uploading of radiographic images via VIP.

Future Development

Future development should be aimed at using technology to simplify the procedures to obtain clinical, photographic, and radiographic records:

- Digitization of impressions using a scanner for manipulation and archive of clinical records (as has been developed by at least one company [Bibliocast] in France).
- Replacement of photographs with digital cranial computed tomography (CT) scan images, allowing an individuation of the patient's cranial bones, skin, muscles, and dental arches with teeth and their roots. This information can then be used for better axis control, particularly when treatment includes tooth extraction or planned mesialization.

  With a single examination by cranial CT scan (with a latest generation

scanner with a minimum speed of 80 slices per second), oral impressions, photography, and radiography could be performed at one time through digitization of scanned images that could be directly submitted online to Align Technology. The current multitude of documents, which are subject to errors, would then become unnecessary.

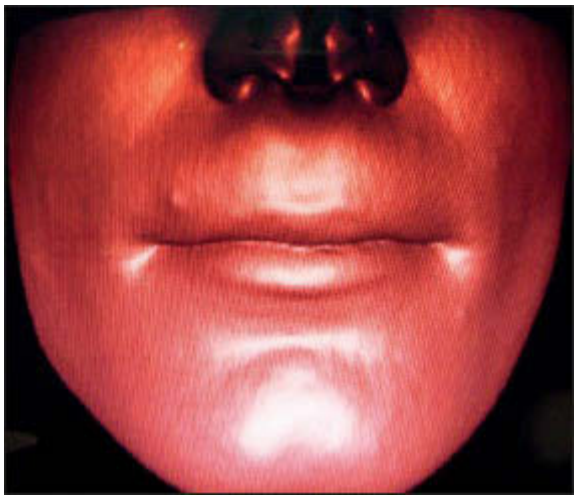


Fig 3-10 Image reconstructed from a cranial CT scan. (Courtesy of S. Ordureau.)

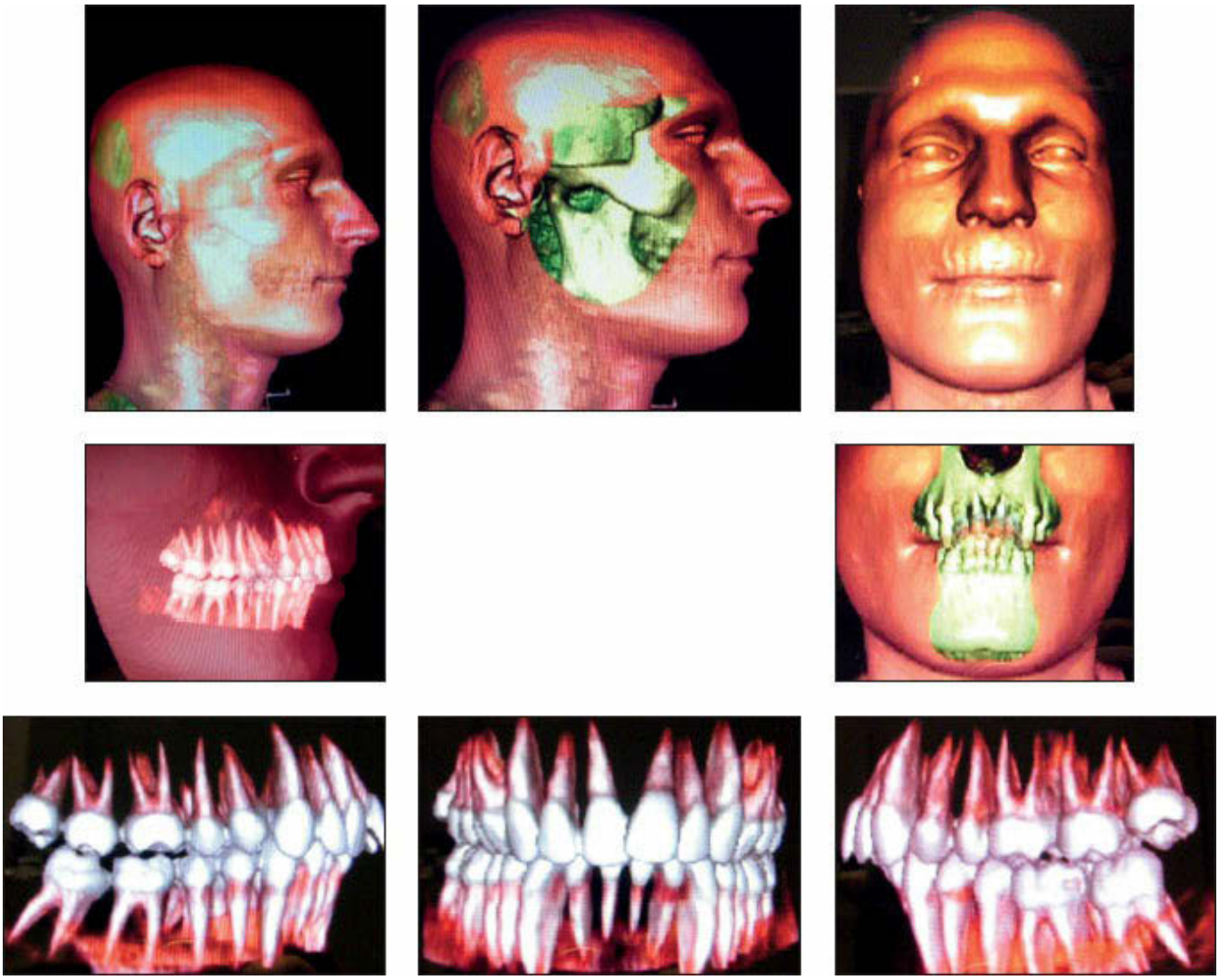


Fig 3-11 Composite of images reconstructed from a cranial CT scan.

Composite of images reconstructed from a CT scan

To achieve the above-mentioned goal, a research trial has been undertaken by the author in collaboration with Sylvain Ordureau at the University of Paris V, France. By using the Useful Progress software developed by Mr Ordureau, three-dimensional (3D) clinical records of the patient's face, dental arches, and teeth with the totality of their roots can be obtained from a single CT scan examination (Fig 3-10). A composite of the images reconstructed from the CT scan (Fig 3-11) could be used for online submission.

This technology paves the way for research to develop 3D control of diagnosis and treatment planning at a detailed level. Before treatment, it would reveal:

- Roots' axes, position in bone, size, and shape
- Simultaneous visualization of the temporomandibular joints and teeth in occlusion
- The dental arches in the soft tissues and their influence on lip position

After treatment, it would show:

- The actual position of molars in case of distalization
- Tooth repositioning by comparison
- Growth by superimposition

Diagnosis and Treatment Plan

4

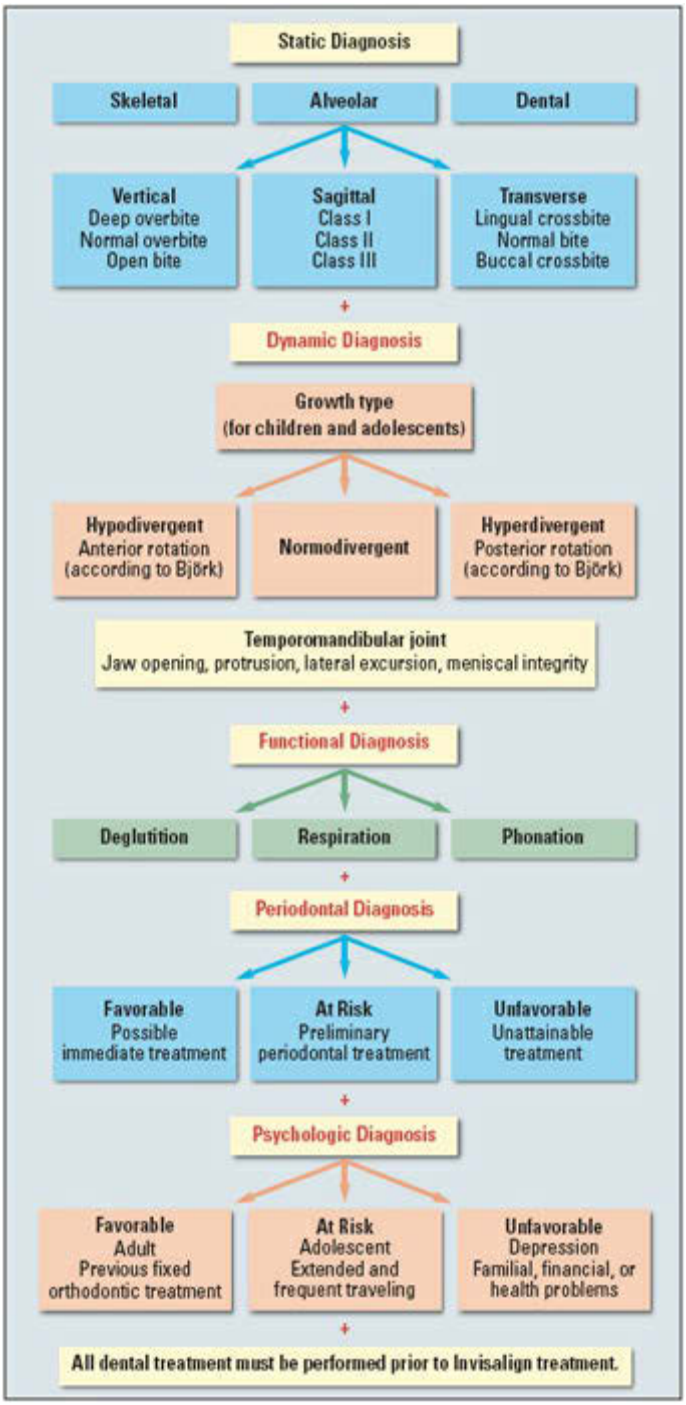


Fig 4-1 Diagnoses required prior to Invisalign treatment.

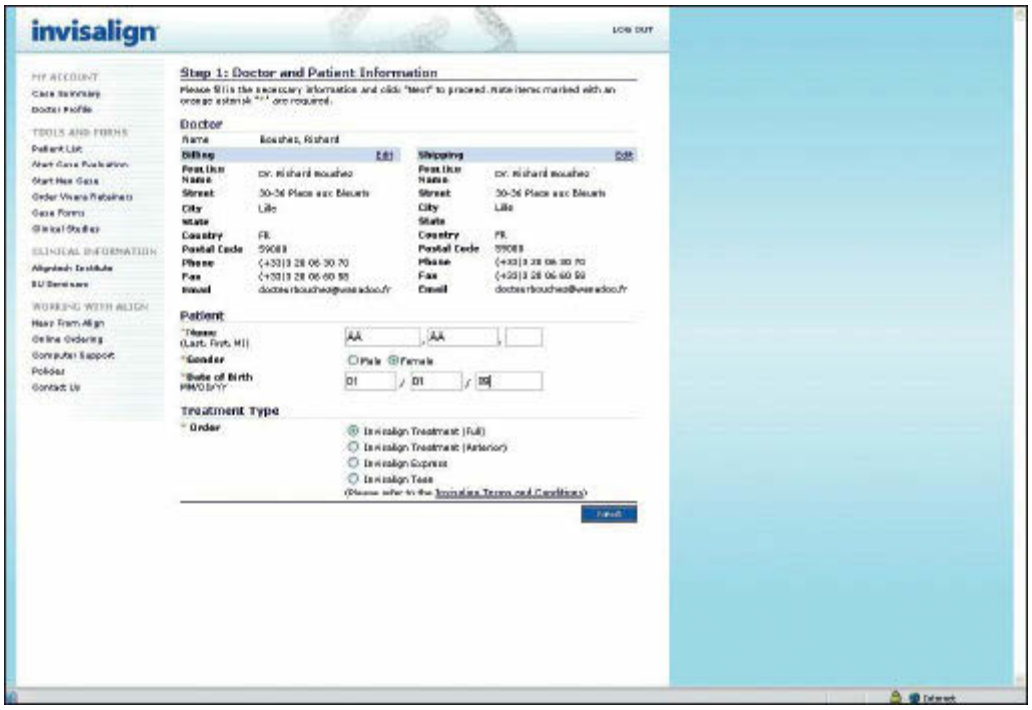


Fig 4-2 Page 1: Information concerning the clinician and the patient as well as the type of treatment are entered. Note that the shipping address for aligners may be different from the billing address.

Diagnosis

The clinician performs a series of diagnoses during the first patient consultation (Fig 4-1). This step is essential to determine the patient's risk. Orthodontists are already familiar with the need for this process from their training and daily practice. Nevertheless, it is worth restating that it is important to first make the diagnoses, then the treatment plan.

Once the diagnoses are made, the clinician then fills in online the treatment plan required by Invisalign for the creation of patient's ClinCheck setup.

Treatment Plan

For those just starting out with Invisalign or in case of treatment doubt, Virtual Invisalign Practice (VIP) provides an assistant tool for treatment planning.

Selecting a treatment type

Invisalign offers four treatment options:

- Full treatment (full arch treatment)
- 3–3 treatment (anterior teeth only—canine to canine)
- Express treatment (simplified variation of full treatment with at maximum 10 aligners per arch and 2 mm of correction of spacing, crowding, and dental midline)
- Teen treatment (for children and adolescents). This book will focus on the other three types of treatment.

The type of treatment must be determined from the beginning (Fig 4-2). In this and in all decisions you make as you are treatment planning, visualize the desired final result, and allow this to guide you. If the results achieved in the treatment simulation are unsatisfactory, a change from full to 3–3 treatment or vice versa is always possible during viewing and modifications of ClinCheck.

Fig 4-3 *(a)* Sagittal discrepancy. *(b)* After 30 months of treatment.

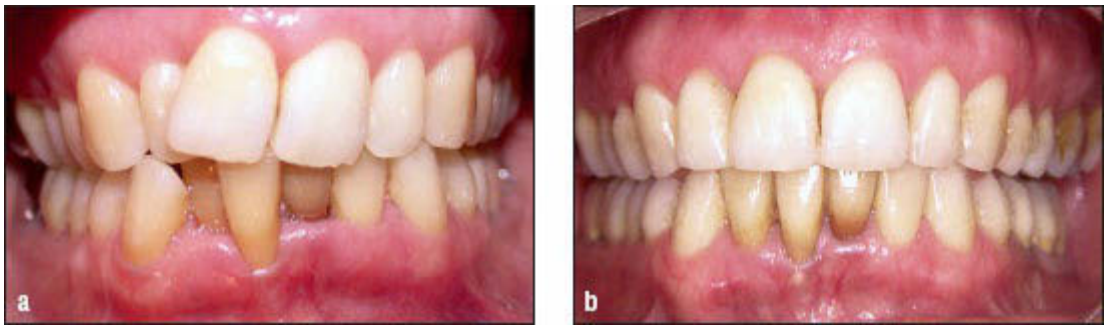


Fig 4-4 *(a)* Transverse discrepancy. *(b)* After 30 months of treatment.

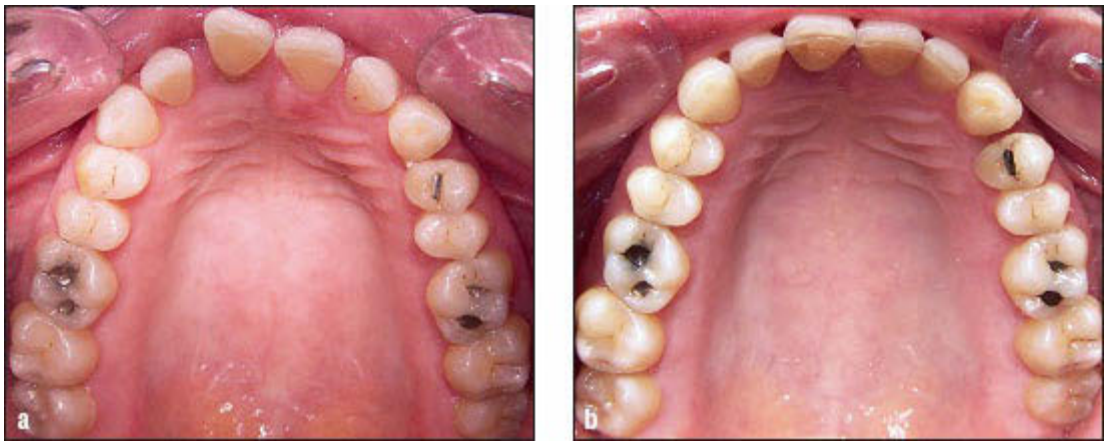


Fig 4-5 *(a)* Dental malpositioning: Rotation of incisor. *(b)* After 14 months of treatment.

Full treatment

In this type of treatment, tooth movements involve all the teeth in both the maxillary and mandibular arches. The treatment, which usually lasts 12 to 30 months, is for functional and esthetic purposes.

This treatment is selected for:

- Sagittal discrepancies with movement of posterior teeth (premolars and molars; distalization and mesialization, extractions, surgical preparations) (Fig 4-3)
- Transverse discrepancies with correction of lingual or buccal crossbite of posterior teeth (premolars and molars) (Fig 4-4)
- Dental malpositioning such as rotation of anterior or posterior teeth or tipping of premolars and molars in cases of crowding; tooth extraction without replacement or prosthetic preparations (Fig 4-5)

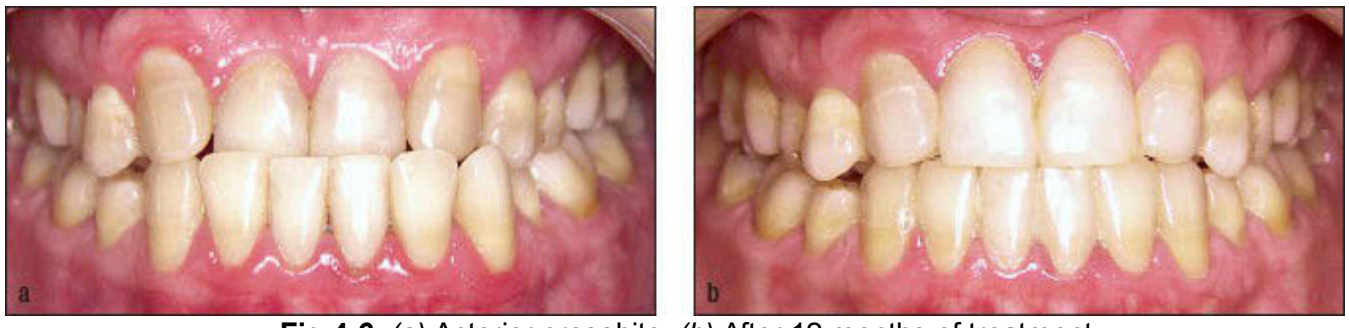


Fig 4-6 *(a)* Anterior crossbite. *(b)* After 12 months of treatment.

Fig 4-7 *(a)* Anterior crowding. *(b)* After 11 months of treatment with molar distalization.

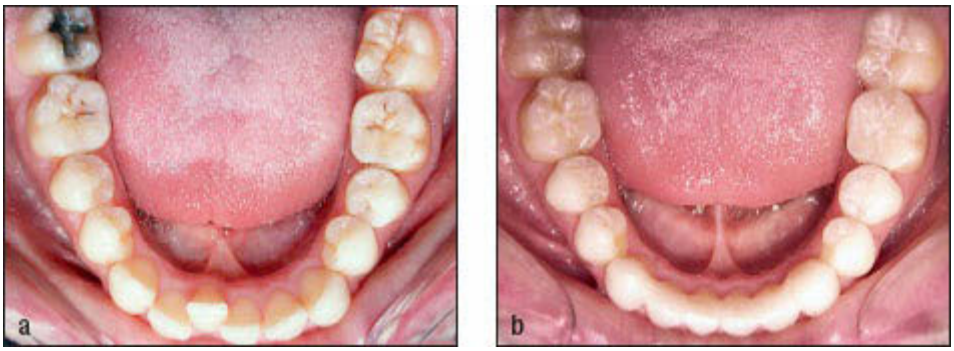


Fig 4-8 *(a)* Dental malpositioning. *(b)* After 5 months of treatment.

3–3 treatment

For 3–3 (anterior) treatment, tooth movements will involve only the teeth from canine to canine in both the maxillary and mandibular arches. It is less expensive than full treatment (approximately 30% of the cost). The treatment is rather short (6 to 12 months) and is for esthetic purposes.

This treatment is selected for:

- Anterior crossbite without correcting sagittal or transverse discrepancies of the arches as a whole (Fig 4-6)
- Anterior crowding, possibly with enamel reduction and/or labial proclination (Fig 4-7)
- Dental malpositioning with correction of rotation or tipping (eg, anterior relapse after fixed orthodontic treatment) (Fig 4-8)

The canine-to-canine alignment is retained by a fiber-reinforced splint (everStick, Stick Tech) bonded under rubber dam. (Retention by S. Gonthier.)

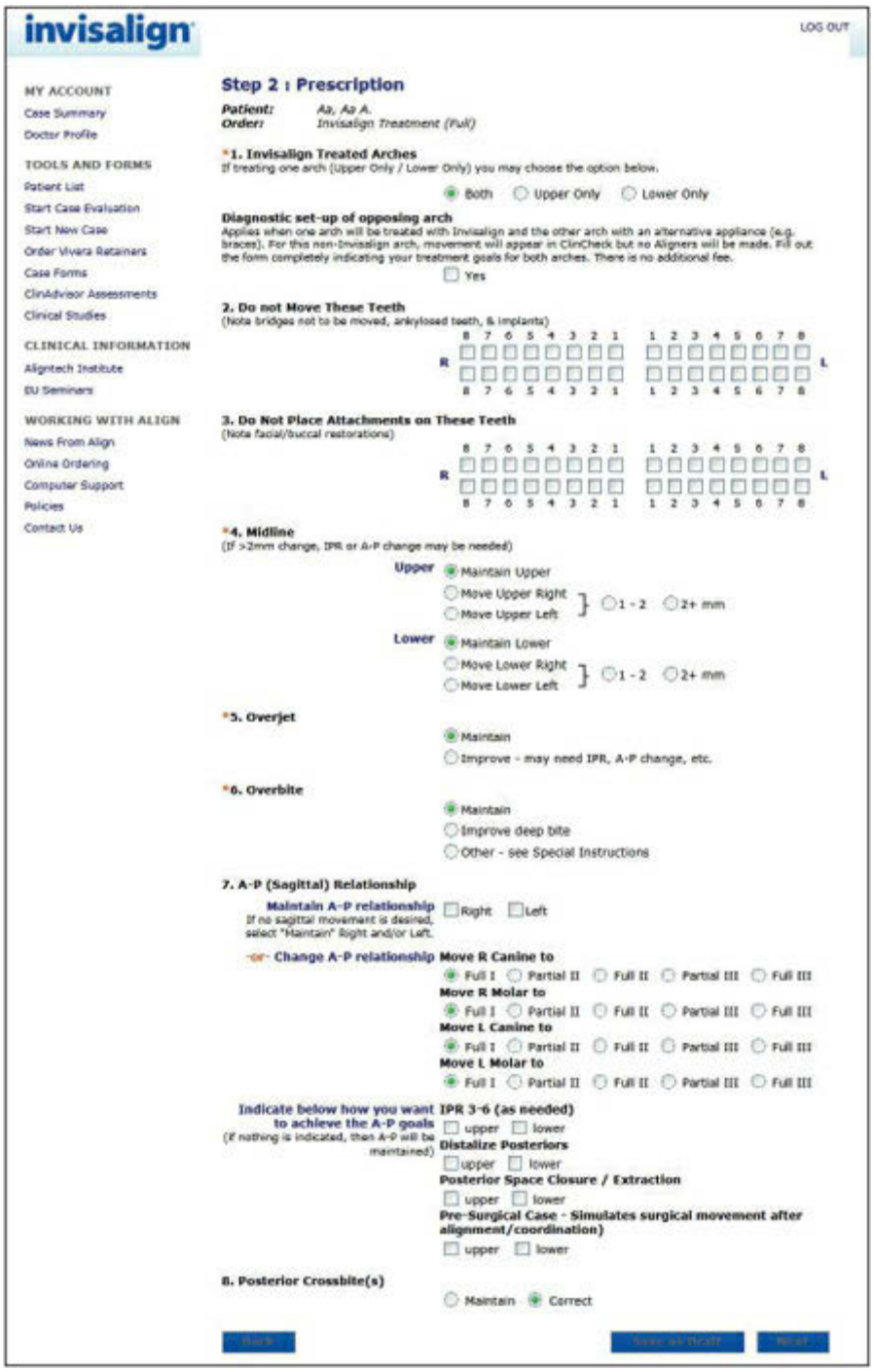


Fig 4-9 Page 1 of the treatment prescription chart.

Treatment prescription chart

The first page of the treatment prescription chart is shown in Fig 4-9. The numbered headings in this section correspond to the VIP prescription steps.

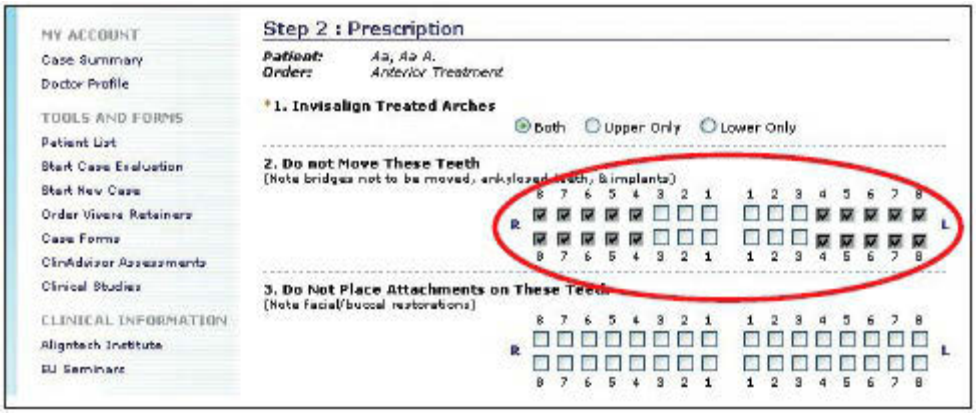


Fig 4-10 Teeth not to be moved in the 3–3 treatment are automatically checked.

1. Treated arches

Three treatment options are proposed:

- Both arches
- Maxilla only
- Mandible only

In many cases the cost is the same for treating one or two arches. It is thus advised to plan treatment on both arches.

2. Teeth to be moved

For 3–3 treatment, posterior teeth not to be moved are automatically checked (Fig 4-10). For 3–3 and full treatment, teeth that are not to be moved and should be checked are:

- Prostheses:
  - —Implant-supported teeth
  - —Partial denture abutments
  - —Absent teeth (extractions, partial denture pontics)
- Teeth at risk:
  - —Teeth with root resorption
  - —Primary teeth
  - —Mobile teeth with severe loss of supporting bone

3. Attachments to be placed

Indications, types, and placement techniques of attachments are presented in chapter 5. Step 3, “Do Not Place Attachments on These Teeth,” concerns only teeth that cannot receive composite resin attachments, which serve later in treatment to control tooth movement. These teeth include:

- Teeth with reconstructions, eg, amalgam restorations on the buccal surface, onlays, or crowns
- Destroyed, sensitive (from periodontal inflammation), severely mobile teeth that cannot withstand the pulling force during removal of the aligner
- Teeth planned for extraction
- Malposed teeth (Fig 4-11)

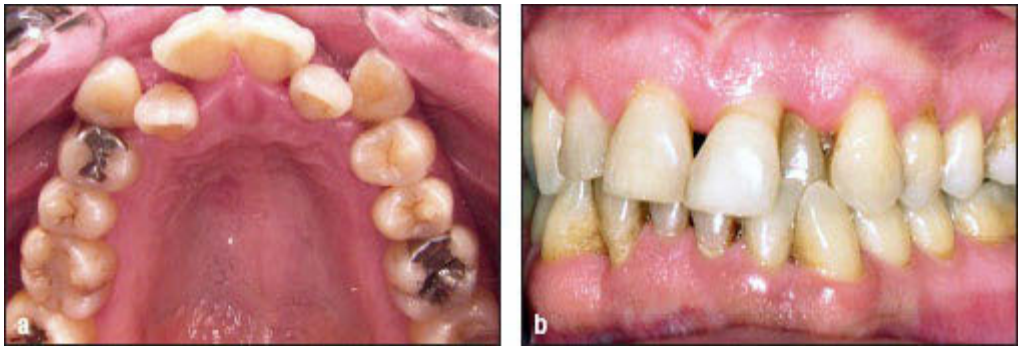


Fig 4-11 *(a and b)* Example of malposed teeth.

Fig 4-12 *(a to e)* Example of dilapidated dental arches with multiple reconstructions and edentulousness.

One advantage of Invisalign is its ability to move teeth under any dental or prosthetic support and in the presence of any type of partial edentulousness (Fig 4-12).

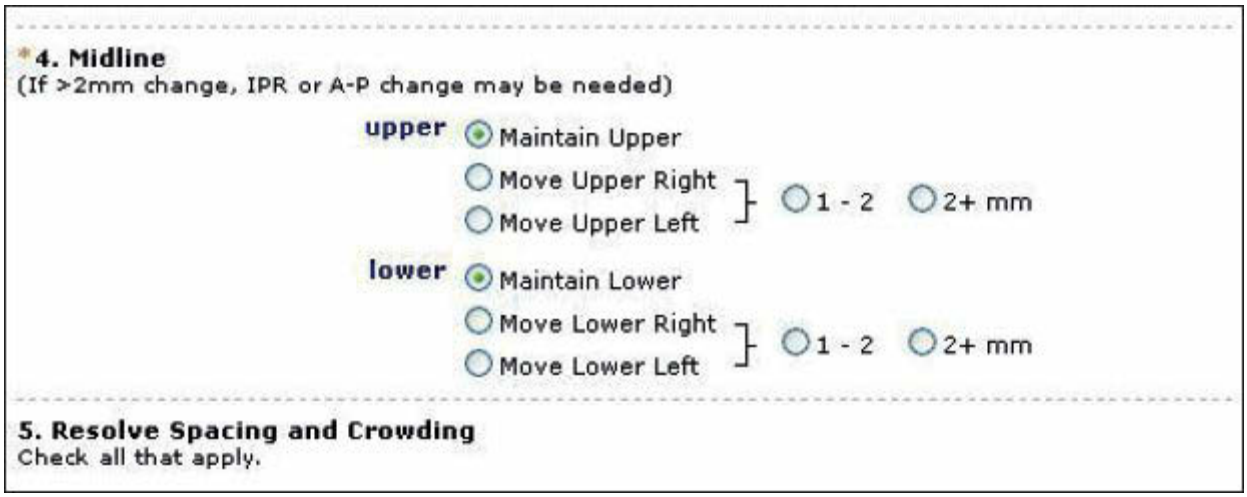


Fig 4-13 Any desired midline change is noted at step 4.

Fig 4-14 Inclined midline deviation.

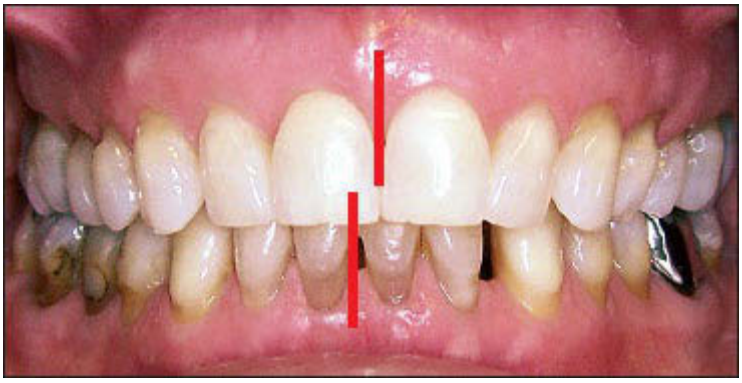


Fig 4-15 Midline deviation to the right.

4. Midline determination

Midline deviations can be more or less accentuated and require correction. Align technicians will set up ClinCheck based on the patient's photographs and the clinician's indication as to whether and how to correct the midline. The clinician cannot proceed to the next page without determining the desired midline by checking the appropriate boxes (Fig 4-13). Any movement of more than 2 mm of a dental midline will require significant enamel reduction, distalization, or extraction. Changing the midline reduces the amount of space available to correct crowding.

During impression taking, be sure to note any movement necessary for a midline shift, or use the extraoral frontal smiling photo to determine the relationship of dental and facial midlines and the amount of required correction. Take into account the amount of tooth inclination (Fig 4-14) in the calculation of midline correction (Fig 4-15).

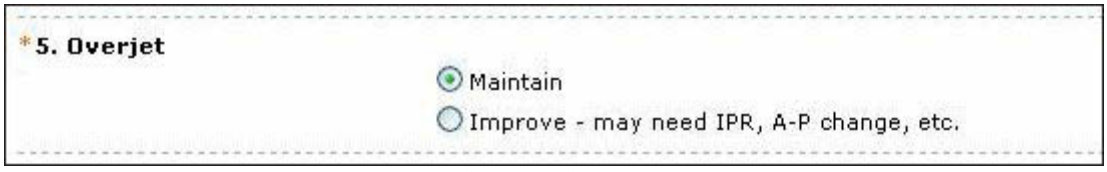


Fig 4-16 Step 5: Overjet correction.

5. Overjet

Steps 5 to 8 on the prescription charts are different depending on whether full or 3–3 treatment has been chosen. Treatment of the following items will not exist in the 3–3 treatment chart:

- Overjet
- Overbite
- Sagittal (anteroposterior, A-P) relationship
- Posterior crossbite

Overjet treatment presents two options (Fig 4-16):

- The patient's clinical overjet is maintained. This option is selected in cases of Class I occlusion without anterior alveolar protrusion to be corrected or where it is the therapeutic choice of the clinician and/or the patient not to modify the A-P position of the incisors.
- The overjet is modified:

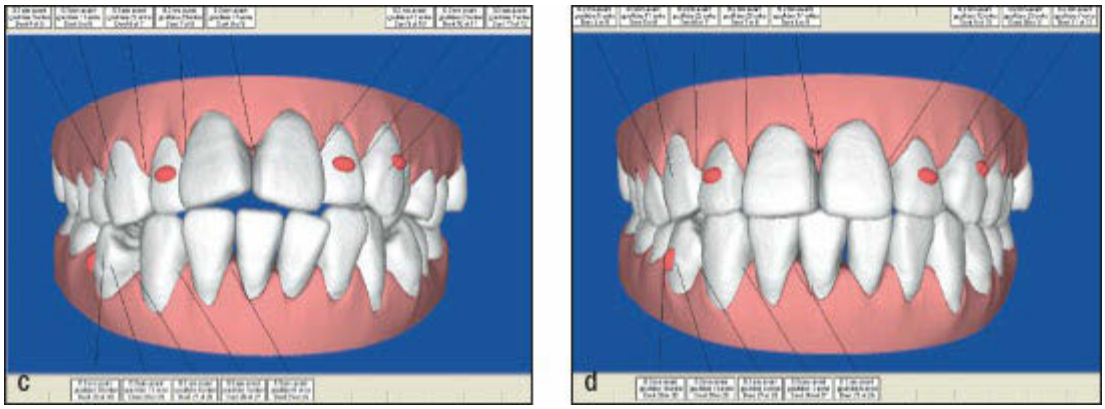
—Without interproximal reduction (IPR) or distalization, eg, anterior diastema closure

—With IPR and/or distalization, when it is to correct an overjet related to Class II occlusion or an unesthetic anterior alveolar protrusion

An example of overjet correction with IPR and without midline modification is shown in Fig 4-17.

Fig 4-17a Overjet requiring correction with IPR.

Fig 4-17b After 19 months of treatment.



Figs 4-17c and 4-17d ClinCheck before *(c)* and after *(d)* treatment. The amount, staging, and location of IPR as well as the position of attachments are shown. The clinical result shown in Fig 4-17b is in accord with the simulation.

Figs 4-17e and 4-17f Right lateral view before (e) and after (f) treatment.

Figs 4-17g and 4-17h Maxillary occlusal view before *(g)* and after *(h)* treatment. Slight relapse of labial tipping occurred on the right central incisor because of poor patient compliance in wearing the removable retainer prior to bonded retention with a fiber-reinforced splint from canine to canine.

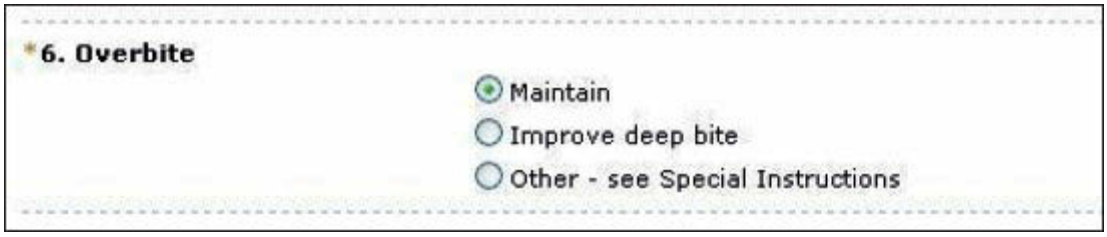


Fig 4-18 Step 6: Overbite correction.

Fig 4-19 *(a)* Deep overbite. *(b)* After deep overbite correction with leveling of the dental arches using aligners and mandibular surgery (Obwegeser technique). (Surgery by C. Rose.)

6. Overbite

Three options for correcting overbite are proposed (Fig 4-18):

- The patient's clinical overbite is maintained. This option is selected in cases where the occlusion is satisfactory or where it is the intentional therapeutic choice of the clinician and/or the patient not to modify the vertical position of incisors.
- The overbite is modified, within predictable clinical limits, by placement of attachments for intrusion or extrusion (see chapter 5).
- Special instructions are given, eg, surgical treatment of a Class II, division 2 malocclusion to correct the overbite (Fig 4-19). Details are noted on the prescription chart in the section "Special Instructions."

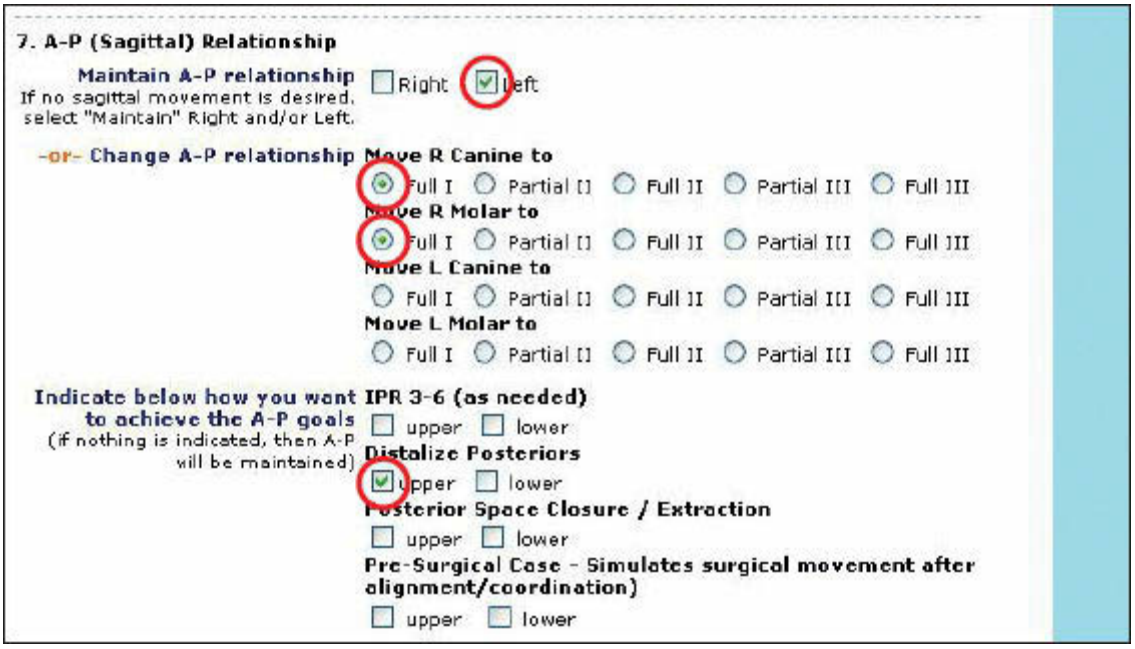


Fig 4-20 Step 7: A-P relationship correction.

7. A-P (sagittal) relationship

This important step will determine how sagittal discrepancies of the arches will be resolved (Fig 4-20). It depends upon:

- The established diagnosis. Correction of Class II malocclusion is planned differently depending on whether the underlying cause is maxillary protrusion or mandibular retrusion. Correction of Class III malocclusion is also different based on whether the diagnosis is maxillary retrusion/hypoplasia or mandibular protrusion. The treatment plan likewise depends on factors such as whether the discrepancy is skeletal or

alveolar, the compensation component due to tooth position, and any associated mandibular movement such as functional slide.

- The treatment goals. Is the Class II malocclusion to be corrected unilaterally or bilaterally? Is the correction planned to totally or only partially treat the Class II malocclusion? For example, will there be extraction of maxillary premolars, with an establishment of a Class I canine relationship and therapeutic Class II molar relationship?
- How the goals are to be achieved. Correction can be obtained by IPR, distalization, extraction, or surgical intervention. All these means can be combined, eg, limited distalization by IPR on premolars and molars (to reduce the amount of tooth movement and thus the number of stagings), extraction on one side and distalization on the other, or distalization on one side and IPR on the other. Finally, Class II or Class III intermaxillary elastic traction may be necessary to serve as anchorage control during distalization or corrective treatment of arch discrepancies.

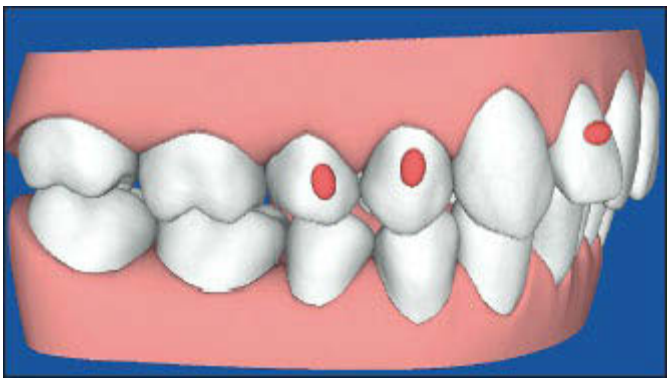


Fig 4-21a Before treatment.

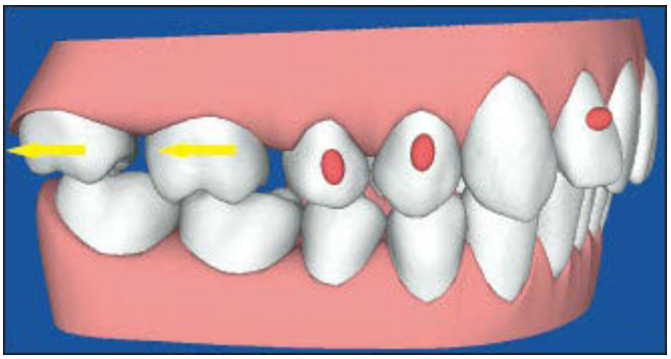


Fig 4-21b Stage 10: Establishment of Class I molar relationship.

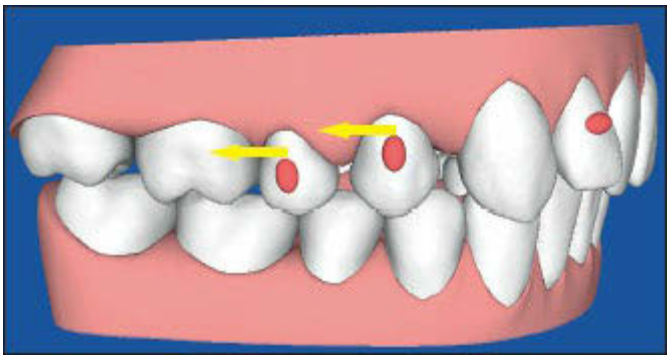


Fig 4-21c Stage 20: Establishment of Class I premolar and canine relationship.

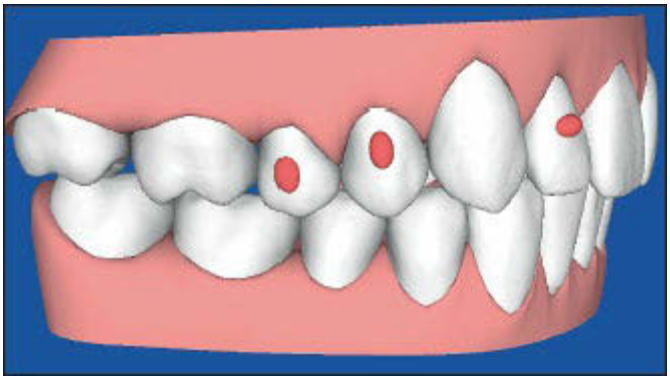


Fig 4-21d Stage 42: End of treatment.

Figure 4-21 shows the clinical case corresponding to the example of sagittal correction prescription shown in Fig 4-20. The patient presented with a Class I left and Class II right malocclusion; therefore, the A-P relationship must be maintained on the left side, and a Class I occlusion must be established on the right side by molar, then premolar, and finally canine distalization. Note the 1-mm midline correction to the right in the maxilla. The establishment of Class I canine and molar relationships is done by distalization. Class II maxillomandibular elastic traction is added during distalization for anterior anchorage control.

Fig 4-21 *(e to i)* Clinical condition before treatment.

Fig 4-21 *(j to n)* After 21 months of treatment.

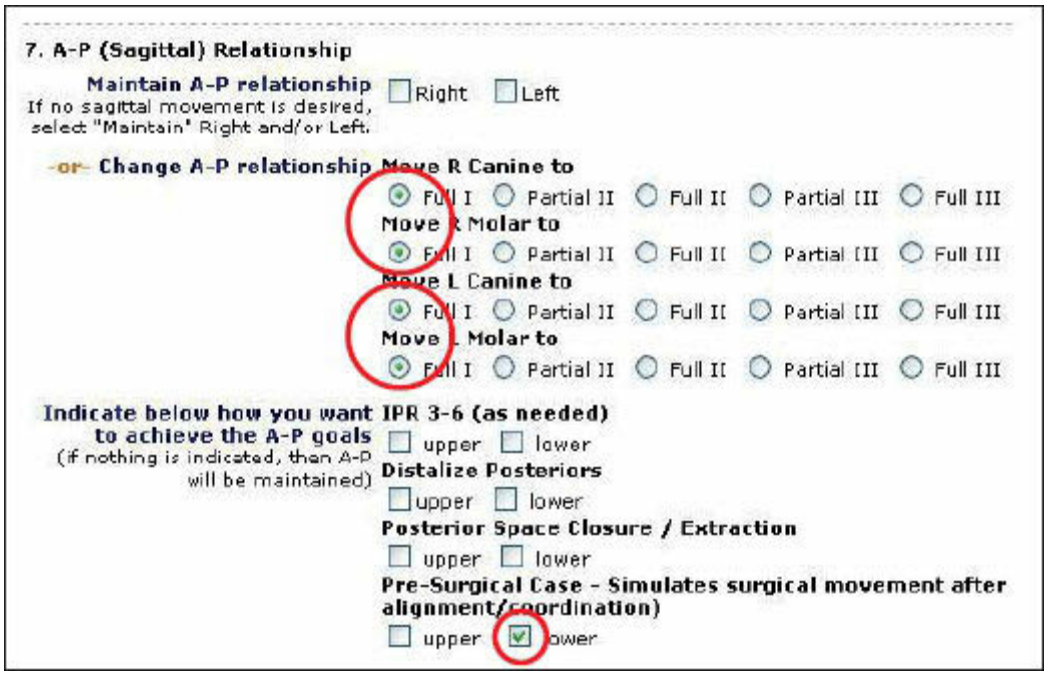


Fig 4-22 Prescription chart marked for surgical treatment.

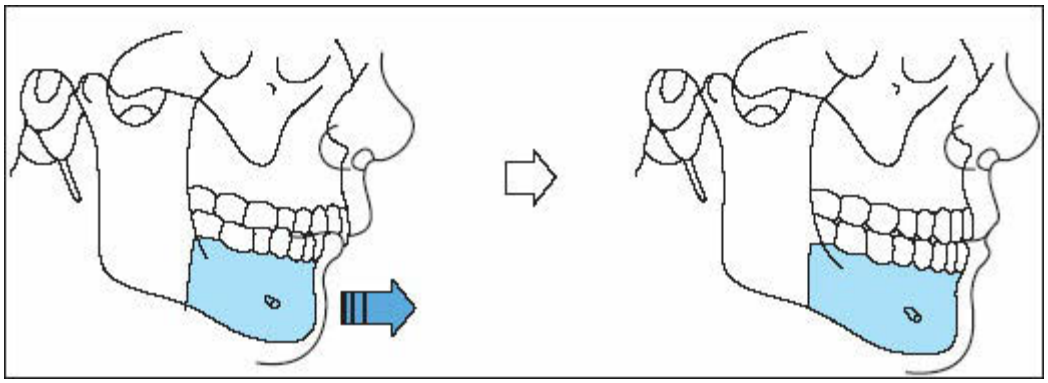


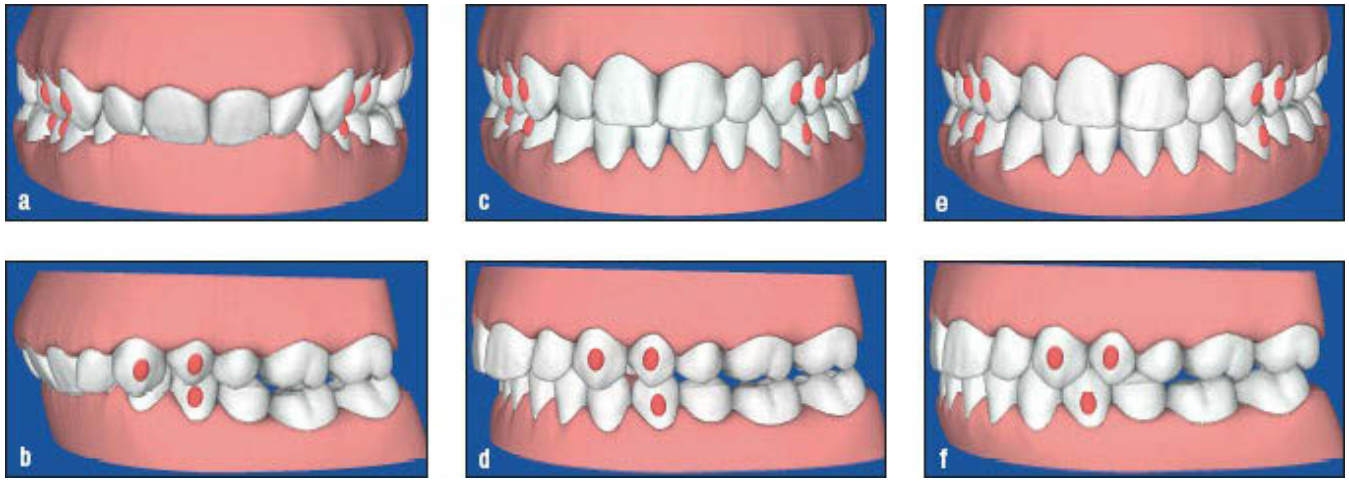
Fig 4-23 Mandibular osteotomy using the Dal Pont-Obwegeser technique. (Courtesy of C. Bernard.)

Surgical treatment prescription: Case example

The patient presents a hypodivergent facial pattern and Class II, division 2 malocclusion requiring orthosurgical correction to create a Class I occlusion. To obtain presurgical occlusal preparation and coordination of the dental arches, "Full I" was selected on the prescription chart for right and left canines and molars (Fig 4-22).

A mandibular advancement osteotomy using the Dal Pont-Obwegeser technique (Fig 4-23) was planned following Invisalign treatment. The box next to "lower" under "Pre-Surgical Case—Simulates surgical movement after alignment/coordination" was thus selected (see Fig 4-22).

Figure 4-24 demonstrates how treatment with aligners corrected the Class II, division 2 malocclusion by leveling and coordinating the arches and proclining the incisors. The established Class I occlusion and the correction of the midline shift (present before the mandibular surgery) are shown.



Figs 4-24a to 4-24f ClinCheck before treatment *(a and b)*, after aligners *(c and d)*, and after surgery *(e and f)*.

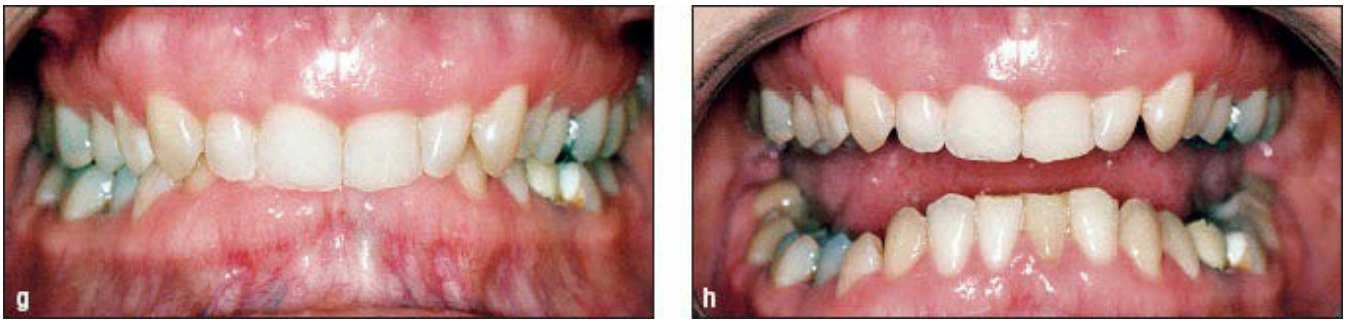


Fig 4-24 *(g and h)* Deep overbite before treatment.

Fig 4-24 *(i to l)* After treatment. (Surgery by C. Rose.)

Fig 4-25 Prescription chart marked for posterior crossbite correction.

Fig 4-26 *(a to c)* Patient with posterior crossbite. Before treatment.

Fig 4-26 *(d to f)* Stage 17 aligners.

Fig 4-26 *(g to i)* After treatment.

Figs 4-26j to 4-26l Maxillary occlusal views before aligner treatment *(j)*, with the aligner at stage 17 *(k)*, and after aligner treatment *(l)*.

8. Posterior crossbite(s)

If a posterior (premolar or molar) crossbite exists, the clinician must choose to correct or maintain it (Fig 4-25). The patient shown in Fig 4-26 presented with a bilateral underdeveloped maxilla with left unilateral posterior crossbite, a midline deviation, and an anterior open bite (ie, Cauhepe-Fieux syndrome).

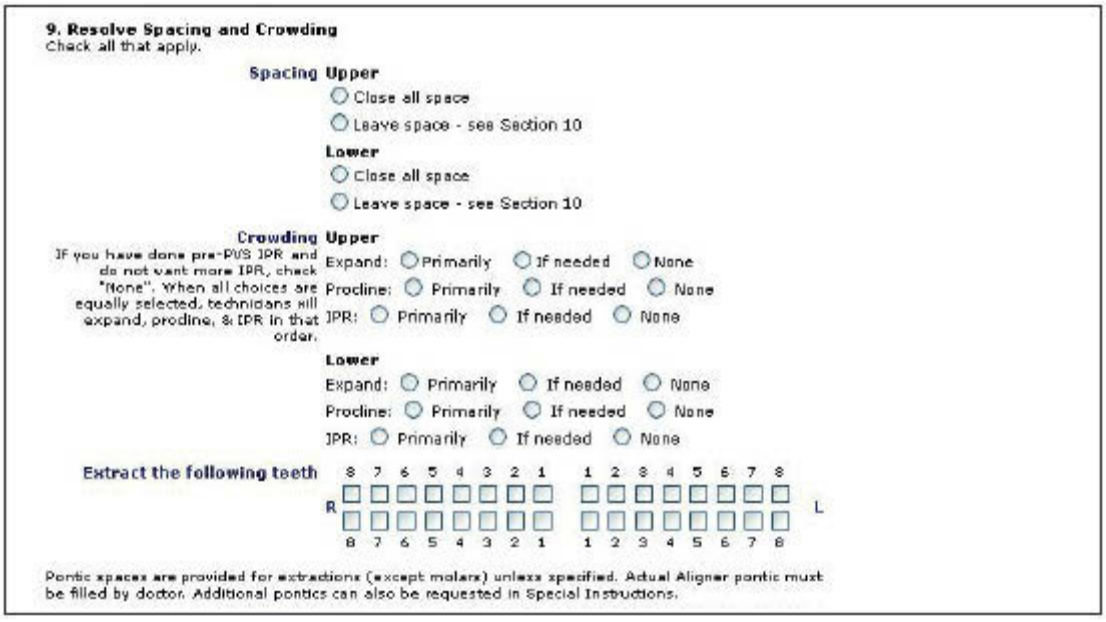


Fig 4-27a Prescription of spacing and crowding treatment for full treatment.

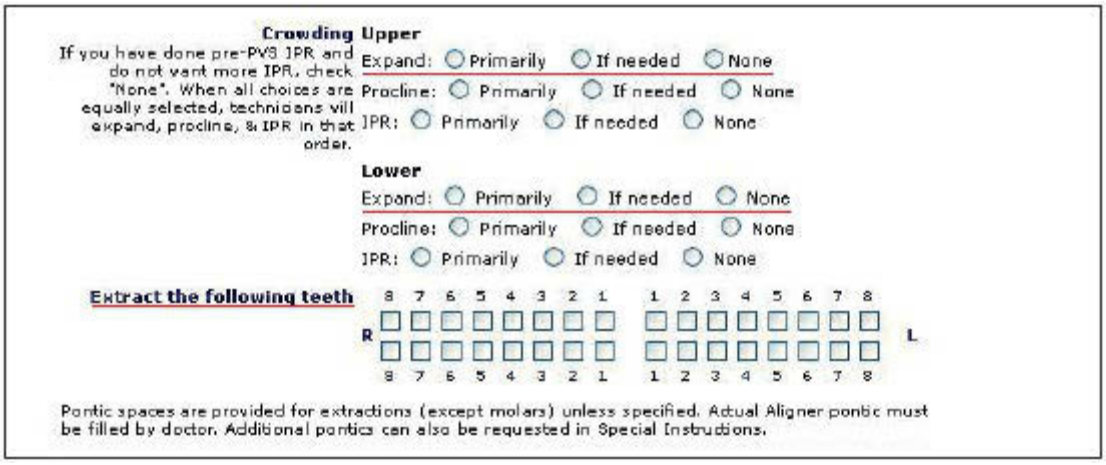


Fig 4-27b Crowding: Full treatment. Note that the options to "Expand" and "Extract the following teeth" are present *(red underline)*.

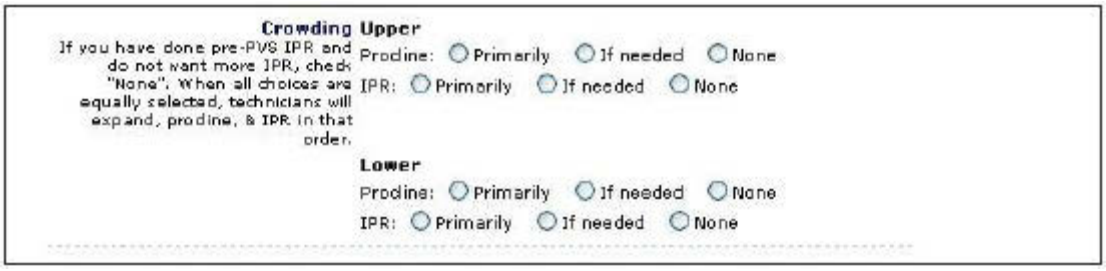


Fig 4-27c Crowding: 3–3 treatment.

9. Resolve spacing and crowding

"Resolve Spacing and Crowding" is step 9 for full treatment (Fig 4-27a) and

step 5 for 3–3 treatment. For 3–3 treatment, the “Expand” and “Extract the following teeth” lines are absent (Figs 4-27b and 4-27c).

At this step, if 3–3 treatment is selected but the space seems to be insufficient to correct crowding without significant enamel reduction or labial tipping, a change to full treatment can be made by restarting from the first page of the prescription. A space can be obtained within the orthodontic biocompatible limit by selecting “Expand” to expand the maxillary arch or by using “Extract the following teeth” to prescribe removal of one or more teeth.

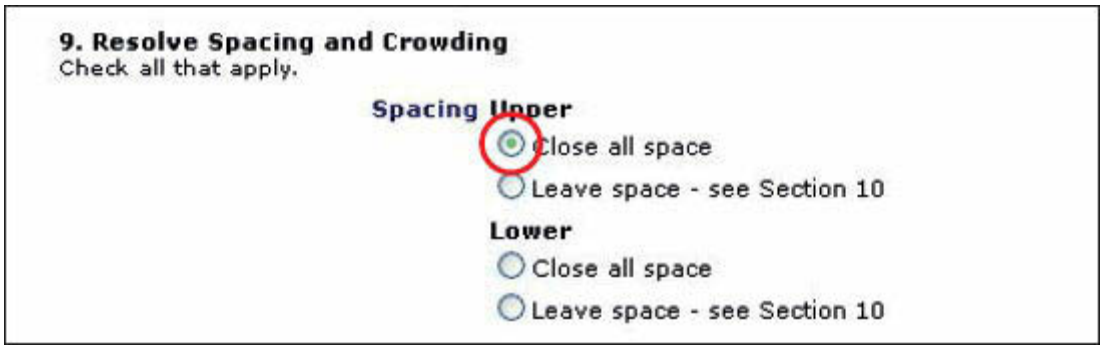


Fig 4-28 Prescription chart marked to close all space.

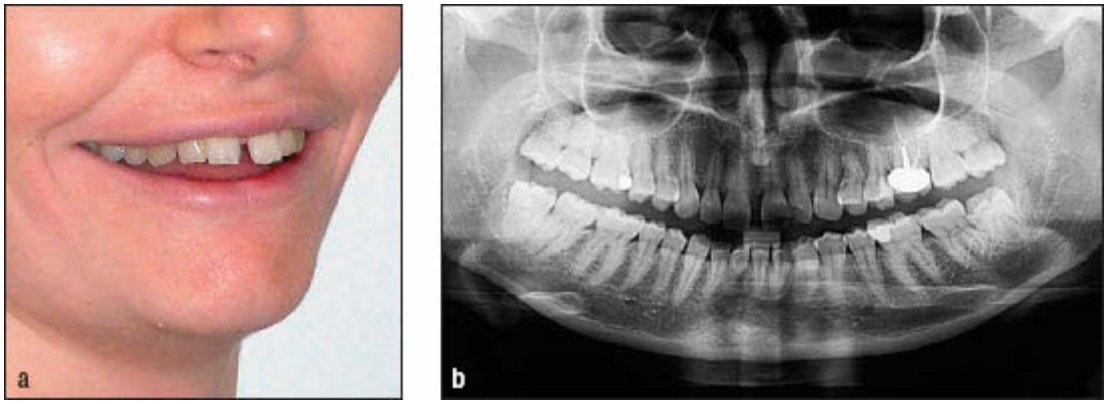


Fig 4-29 *(a and b)* Extraoral and radiographic views of patient with a diastema between her maxillary central incisors.

Resolving spacing

Two options are provided:

- Close all space
- Leave space

Close all space (Fig 4-28)

Closing space is a recommended application for clinicians just starting out with Invisalign treatment. Aligners are very efficient for closing space. An example of a space closure between the maxillary central incisors with 17 aligners is shown in Fig 4-29. To perform sufficient maxillary incisor retraction to close one or several anterior spacings, enamel reduction on mandibular incisors must also be performed to retract these teeth and avoid interarch collisions (see Figs 4-29o and 4-29p).

Fig 4-29 *(c to g)* Intraoral views before treatment.

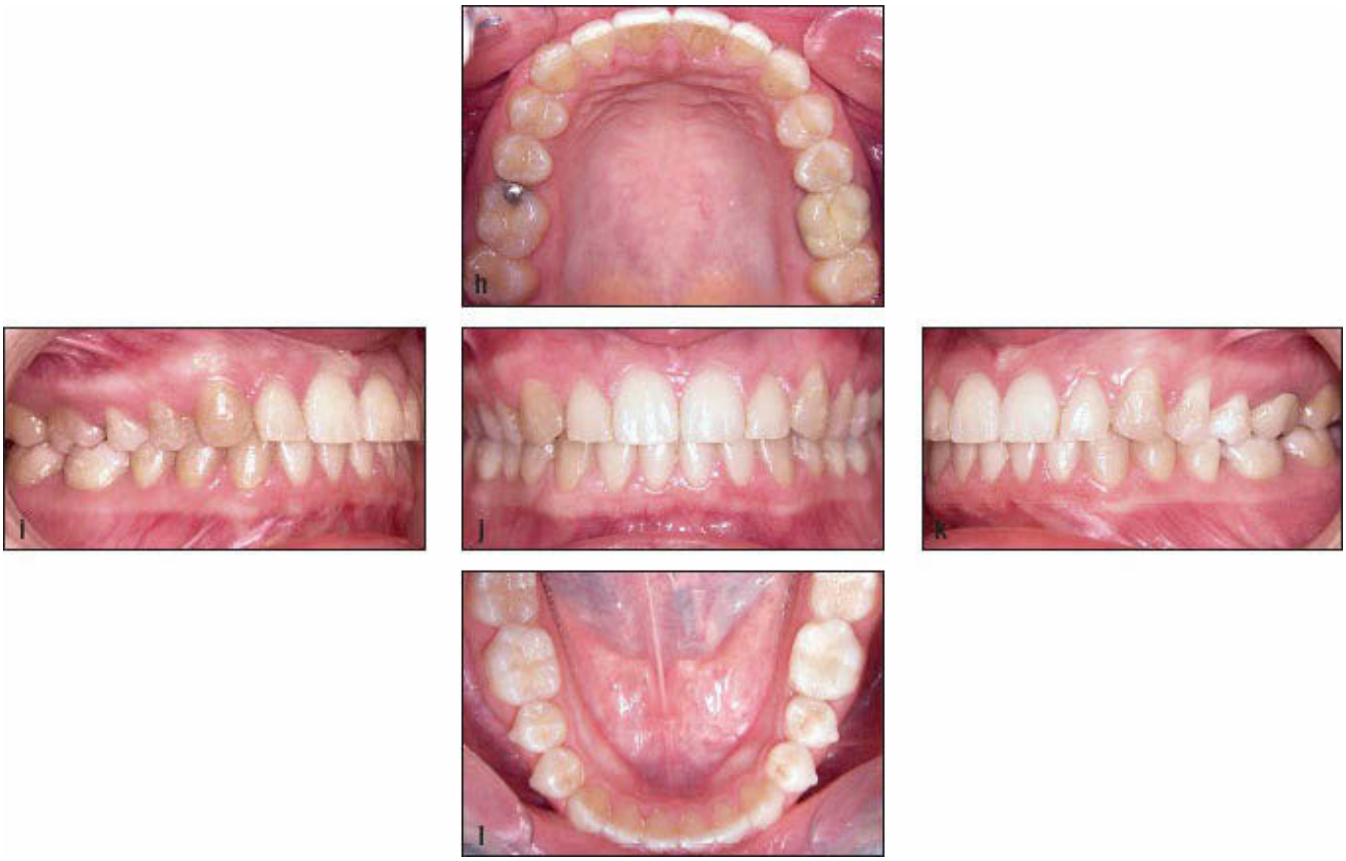


Fig 4-29 *(h to l)* After 8.5 months of treatment with 17 aligners.

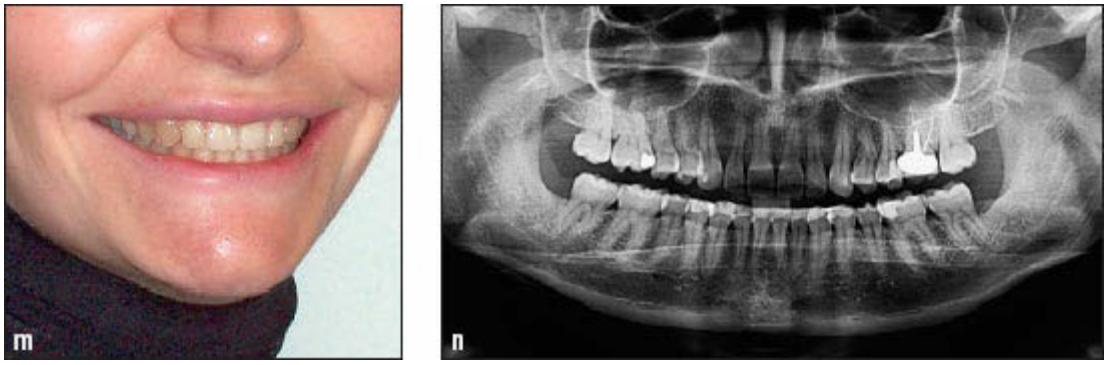


Fig 4-29 *(m and n)* Extraoral and radiographic results.

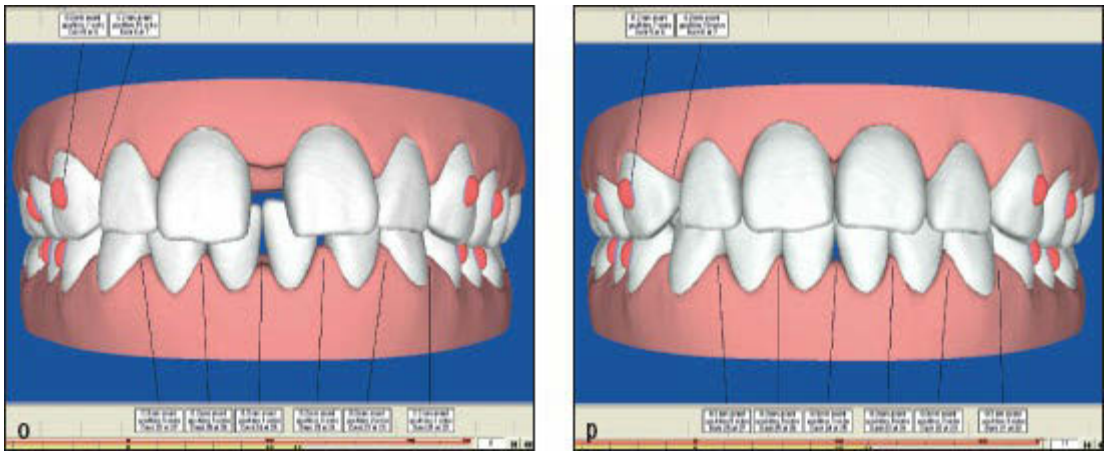


Fig 4-29 *(o and p)* Planning of mandibular incisor enamel reduction.

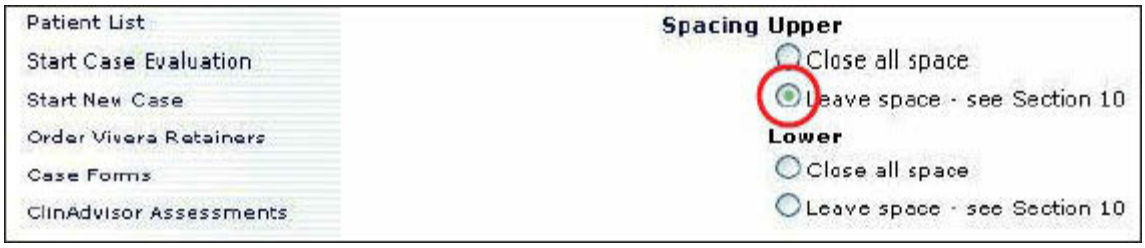


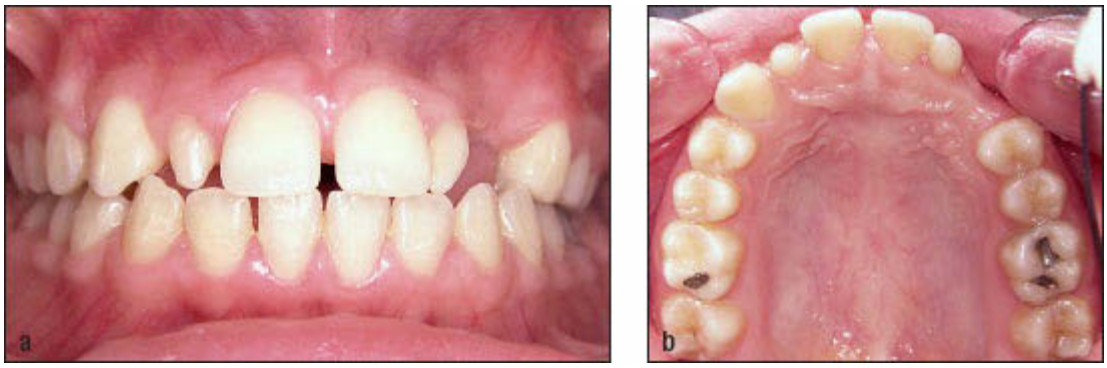
Fig 4-30 Prescription chart marked to leave space.

Leave space (Fig 4-30)

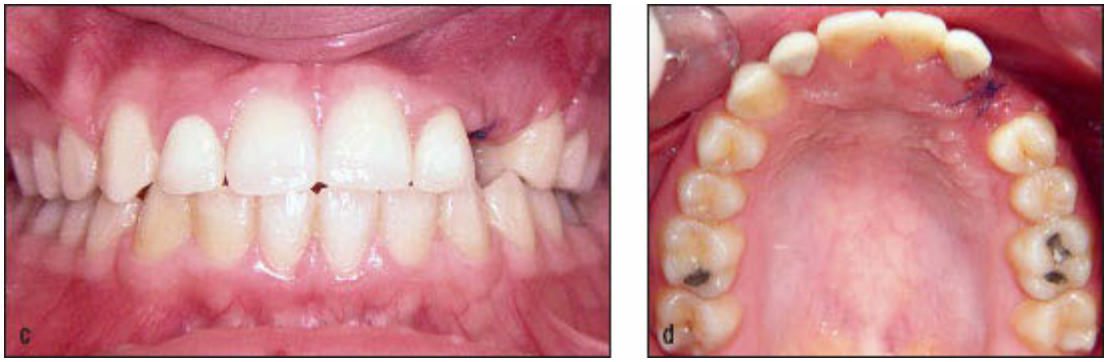
There are two reasons why space may be left:

1. Space is left for a therapeutic reason, eg, planned placement of a prosthesis or implant, restoration of a peg-shaped incisor, or the specific request of the patient. It is necessary to specify to the technician the amount of space required and its location on the arch in the “Special Instructions” section (step 14 for full treatment or step 9 for 3–3 treatment).

   Figure 4-31 provides an example of a case requiring complex anterior spacing correction. The clinician would select “Leave space” for the maxilla and “Close all space” for the mandible. A detailed explanation would be communicated to the technician in the “Special Instructions” section concerning the desired position of both maxillary lateral incisors and the future implant at the left canine site.

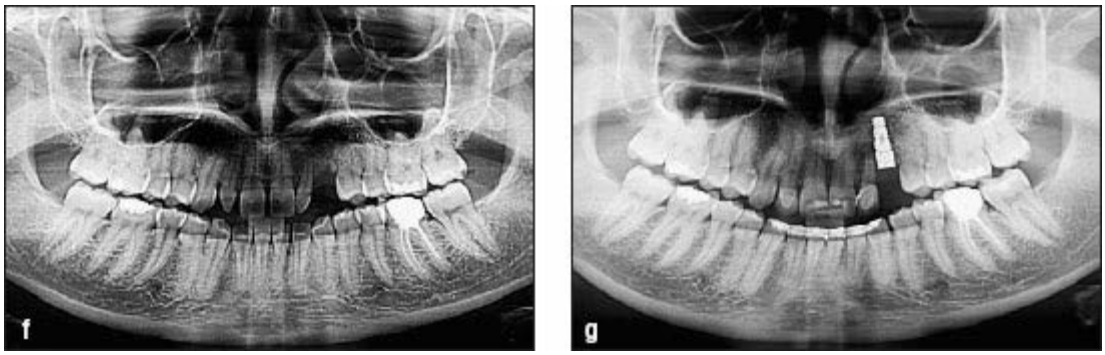


Figs 4-31a and 4-31b Frontal *(a)* and maxillary occlusal *(b)* views of a patient requiring correction of complex anterior spacing.



Figs 4-31c and 4-31d Frontal *(c)* and maxillary occlusal *(d)* views after treatment over the course over 4 months in the maxilla and 5.5 months in the mandible (stage 8 and 11 aligners, respectively). Closure of the space between the central and lateral incisors on both sides of the maxilla positioned them in the middle of the available space, allowing future placement of two provisional crowns on the lateral incisors and an implant in the left canine site.

Fig 4-31e The provisional prosthetic crown in the left canine site is maintained by the aligner.



Figs 4-31f and 4-31g Panoramic radiographs before *(f)* and after *(g)* Invisalign treatment and implant placement.

2. The residual space is due to tooth size discrepancy, and IPR is considered to be undesirable. It is necessary to indicate in the section "Tooth Size Discrepancy" (step 10 for full treatment or step 6 for 3–3 treatment) where the residual space is planned: distal to the lateral incisors or canines (see section on "Tooth Size Discrepancy").

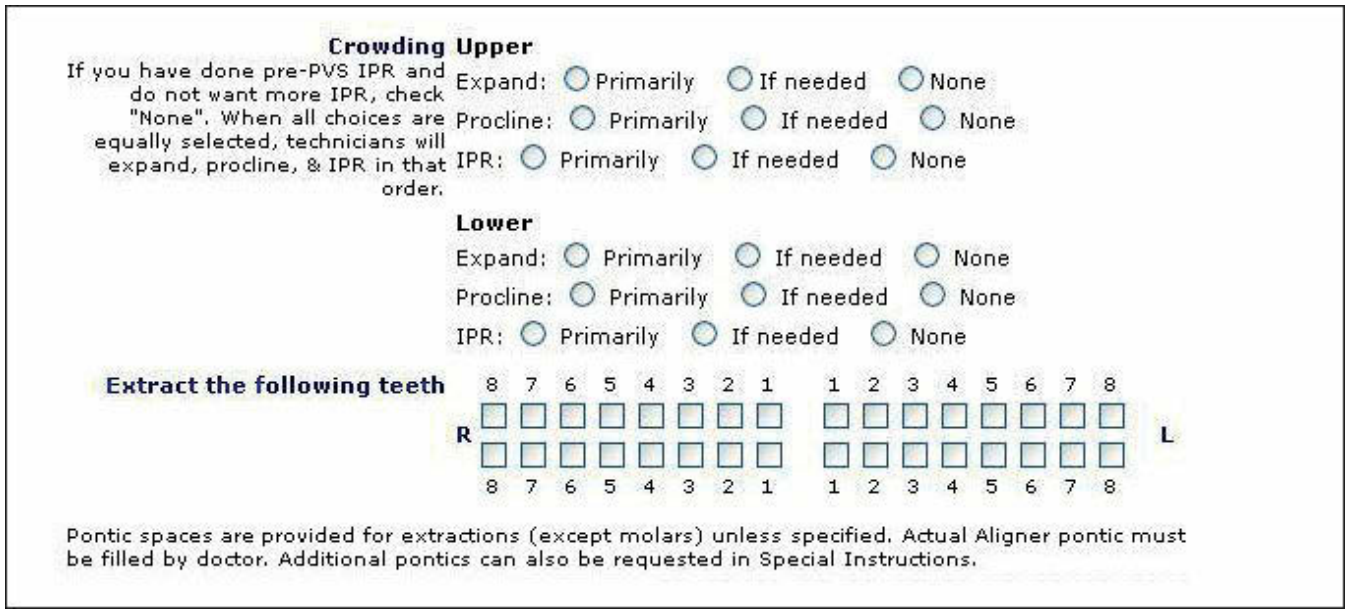


Fig 4-32 Prescription chart for maxillary and mandibular crowding correction.

Resolving crowding

This step (Fig 4-32) is very important since it determines how lack of space in the arches can be resolved. Five options are available:

- IPR performed prior to polyvinyl siloxane (PVS) impression
- Arch transverse expansion (except in 3–3 treatment)

- Anterior segment proclination
- IPR performed during treatment
- Extraction

Clinicians will adapt these means using their own judgment and based on the treatment objectives, their treatment philosophy, and the biomechanics of aligners. Clinicians who do not want to modify the intercanine distance will not expand the arch; those who do not want to perform extraction will perform IPR; and those who do not want to procline will use extraction. However, if the choices are not clearly defined by the clinician and all the options are checked the same (eg, “If needed”), Align technicians will perform the options in the following order by default:

1. Expansion
2. Proclination
3. IPR

Expansion

The choice of arch expansion will be made in case of:

- Underdeveloped maxilla (nonsurgical)
- Uni- or bilateral underdeveloped alveolar bone (ie, due to pressure from the surrounding muscles)
- Posterior lingual crossbite due to tooth crowding

In significant crowding, expansion can be coupled with buccal tipping and, in severe crowding, with IPR.

Important caution: Arch expansion must:

- Be part of a treatment philosophy that includes modifying intercanine width; otherwise, “None” should be selected
- Be compatible with the patient’s anatomical and biologic limits
- Take into account the risk of relapse, eg, due to neuromuscular environment and functions

The decision regarding the arch expansion option should be made based on the treatment objectives defined by the clinician’s diagnosis and treatment plan—not on a default decision by Align technicians—as follows:

- Primarily: Transverse anomalies
- If needed: Mild need for space to avoid IPR
- None: Satisfactory and nonpathologic arch width

Proclination

Anterior proclination will be selected in case of:

- Patient's refusal of IPR
- Mild crowding not requiring IPR
- Labial or lingual muscular dysfunction with lingual tipping of incisors
- Underdeveloped alveolar bone (lip interposition, Class III compensation)
- Lingually positioned teeth due to Class II, division 2 crossbite or crowding

In severe crowding, proclination can be combined with IPR. Important caution: Incisor proclination must:

- Be part of the treatment philosophy because there is a risk of increased lower incisor mandibular plane angle (IMPA), which is very important to those following the Tweed analysis; otherwise, "None" should be selected
- Be compatible with the patient's anatomical and biologic limits since there is a risk of fenestration of alveolar radicular bone or labial gingival dehiscence
- Take into account the risk of relapse due to neuromuscular environment and functions

The decision regarding the anterior proclination option should be made based on the treatment objectives defined by the clinician's diagnosis and treatment plan—not on a default decision by Align technicians—as follows:

- Primarily: A-P anomalies or crowding
- If needed: Mild need for space to avoid IPR
- None: Anterior teeth already in a proclined position

When significant proclination is needed, fixed retention with fiber-reinforced composite splints such as everStick or Ribbond-THM (Ribbond), bonded under rubber dam, must be integrated in the treatment plan.

IPR

IPR on anterior teeth will be selected in case of:

- Mild crowding or dental malposition
- Desire to avoid extraction
- Unfeasibility of expansion or anterior proclination

In cases of severe crowding, IPR can be combined with expansion and labial proclination. Important caution: To perform IPR:

- Technical competence and proper instruments (eg, strips, thickness gauge) are required
- It should be within the patient's anatomical and biologic limits, eg, enamel thickness, sensitivity to hot and cold
- The initial tooth position must be taken into account, including whether there is sufficient space to allow use of the required instruments

The decision regarding the IPR option should be made based on the treatment objectives defined by the clinician's diagnosis and treatment plan —not on a default decision by Align technicians—as follows:

- Primarily: Anterior crowding in adult
- If needed: Mild need for space to avoid labial tipping
- None: Existing lingual crossbite position of anterior teeth

In adult patients, IPR is preferred over extractions when possible, in particular in the mandibular incisors to obtain a better esthetic result and improve alignment of the dental midline.

IPR can be performed prior to the PVS impression. The impression is transmitted to Align Technology so that the amount of movements necessary to close the spaces created by IPR can be planned via ClinCheck. Aligners are fabricated in the number necessary for the complete closure of the created space. This eliminates the risk of over- or under-reduction during the course of treatment.

Staging for IPR is modified using ClinCheck. Strippings are planned later for teeth already partially rotated or repositioned to reduce errors from grinding and other factors. (See chapter 5).

The amount of the lack of space on study casts before IPR and the

amount of IPR performed in the mouth should be measured with gauges so that they coincide. IPR techniques are detailed in chapter 5.

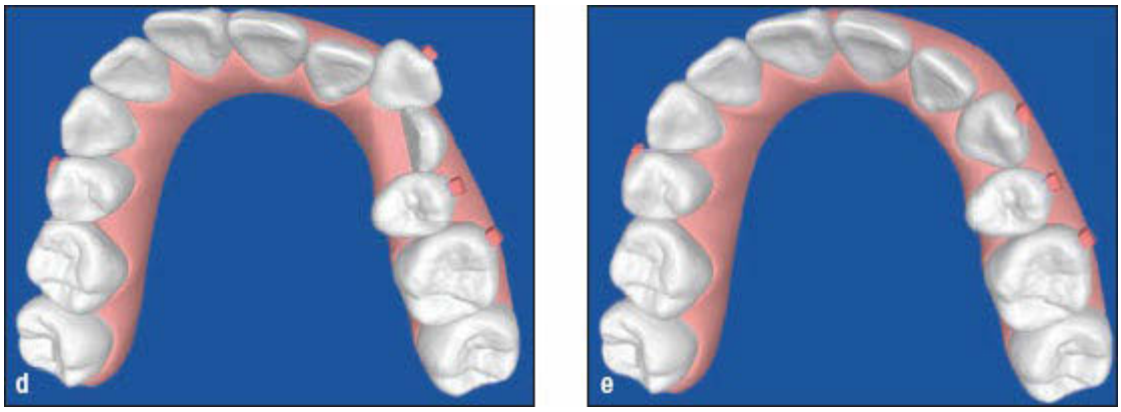
Extraction

The decision whether to extract teeth is made based on the treatment objectives defined by the clinician's diagnosis and the treatment plan. When extraction of teeth is planned, the corresponding box(es) under "Extract the following teeth" must be selected. For example, if removal of one or more third molars is planned but the PVS impression of the arches is performed before extraction, the third molar(s) are selected on the chart and virtually extracted by the technician in ClinCheck.

If two treatment simulations—with and without extraction—are desired, the one without extraction should always be requested first. It is technically difficult for Align Technology to extract teeth first, then put them back with the TREAT software (Performance Systems Development).

When planning extractions, do not forget to plan attachments for axis control on the adjacent teeth and pontic spaces for esthetics (see chapter 5). Figure 4-33 provides an example of a case in which attachments and a pontic space in the aligner are required after extraction. The pontic space is incorporated into the first aligner, whereas the attachments are not placed until the second aligner is in use to give the patient time to become comfortable wearing and manipulating the aligners.

Figs 4-33a to 4-33c Intraoral photographs before extraction *(a)*, after extraction *(b)*, and with the first aligner (which includes a pontic but no attachments) in place *(c)*.



Figs 4-33d and 4-33e ClinCheck simulation with pontic kit and attachments. *(d)* Creation of a pontic and planned attachments following extraction. *(e)* End of treatment.

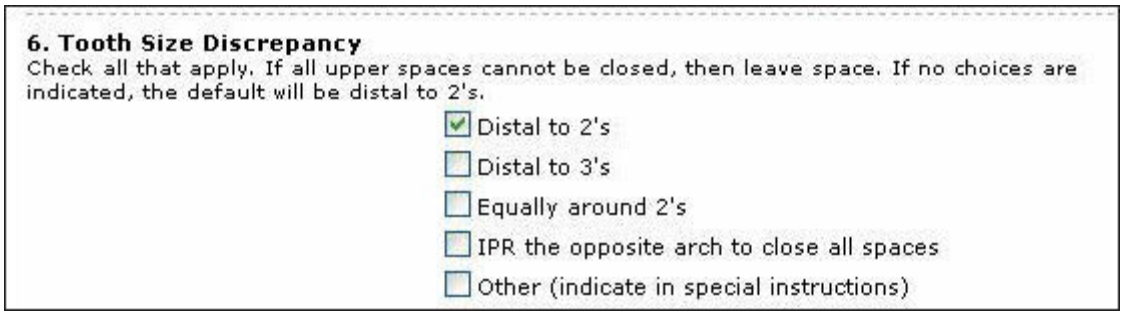


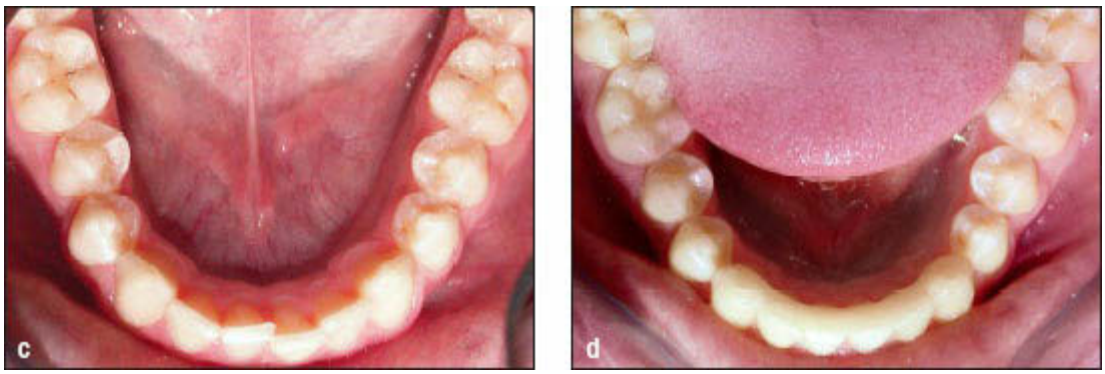
Fig 4-34 Prescription chart for tooth size discrepancy correction.

10. Tooth size discrepancy

As discussed in the section on the option to “Leave space,” in case of tooth size discrepancy (difference in size between the maxillary and mandibular teeth, often accompanied with occlusal disharmony), the location of residual space after anterior space closure must be determined (Fig 4-34):

- Distal to the lateral incisors (“2’s”)
- Distal to the canines (“3’s”)
- Equally around the lateral incisors
- IPR on the opposite arch to close all spaces
- Other (This option is selected when the desired location is different than the proposed ones. An explanation must be provided in the “Special Instructions” section—step 14 in full treatment or step 9 in 3–3 treatment.)

Figs 4-35a and 4-35b Residual space located distal to the maxillary canines and fixed retention with Ribbond-THM splint. (Retention by S. Gonthier.) *(a)* Before treatment. *(b)* Stage 13 of treatment.



Figs 4-35c and 4-35d Mandibular treatment with 11 aligners. *(c)* Stage 1. *(d)* Stage 11 with bonded splint.

The occlusal incidences of this residual space must be verified in Class I canine relationship:

- From a strictly occlusal point of view, the space is often better positioned distal to the lateral incisors in the maxilla, allowing a harmonious Class I canine occlusion.
- From a strictly esthetic point of view, the space is often better positioned distal to the canines in the maxilla, but this will tend to result in a Class II canine relationship.
- From a retention point of view, the space is often better positioned distal to the canines in the maxilla because it is preferable to place a fiber-reinforced composite retention splint from canine to canine to avoid space reopening. Figure 4-35 shows a case in which space was left distal to the maxillary canines and IPR was performed in the mandible. Retention was provided canine to canine in both arches with a splint.

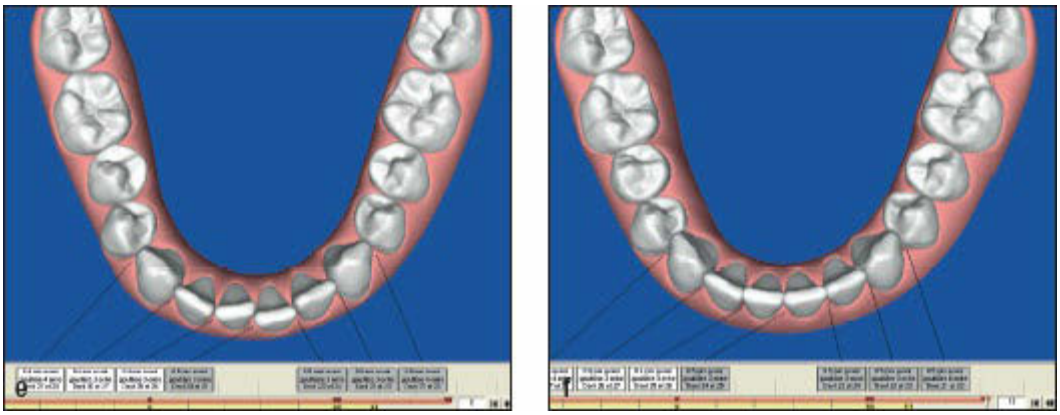
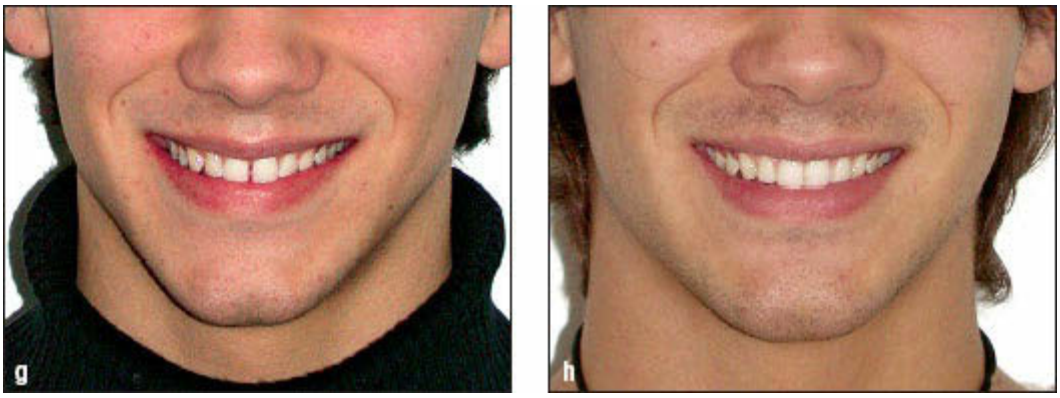


Fig 4-35 *(e and f)* Simulation of correction in ClinCheck.



Figs 4-35g and 4-35h Extraoral view before treatment *(g)* and the esthetic result after treatment *(h)*.

11. Overcorrection
Generalized overcorrection movements do not decrease the need for Refinements due to difficulty in predicting direction and magnitude needed at the beginning of the treatment. If overcorrection is desired for discreet one-dimensional tooth movements, then detailed Special Instructions (#14) are required. Required instructions: tooth number, direction, magnitude.

Example: Overcorrect #9 mesial-in by 5 degrees.

Note: Incomplete information and/or Treatment Preferences regarding overcorrection will not be performed.

Fig 4-36 Prescription chart for overcorrection.

11. Overcorrection

Overcorrection anticipates a difficulty in correcting dental malpositions such as rotation or significant movement such as an establishment of a normal Class I occlusion by distalization. An understanding of aligners' biomechanics is needed to optimize an overcorrection prescription. Align Technology requires precise information concerning the overcorrection prescription (Fig 4-36). A clear and detailed explanation provided in the "Special Instructions" section is obligatory.

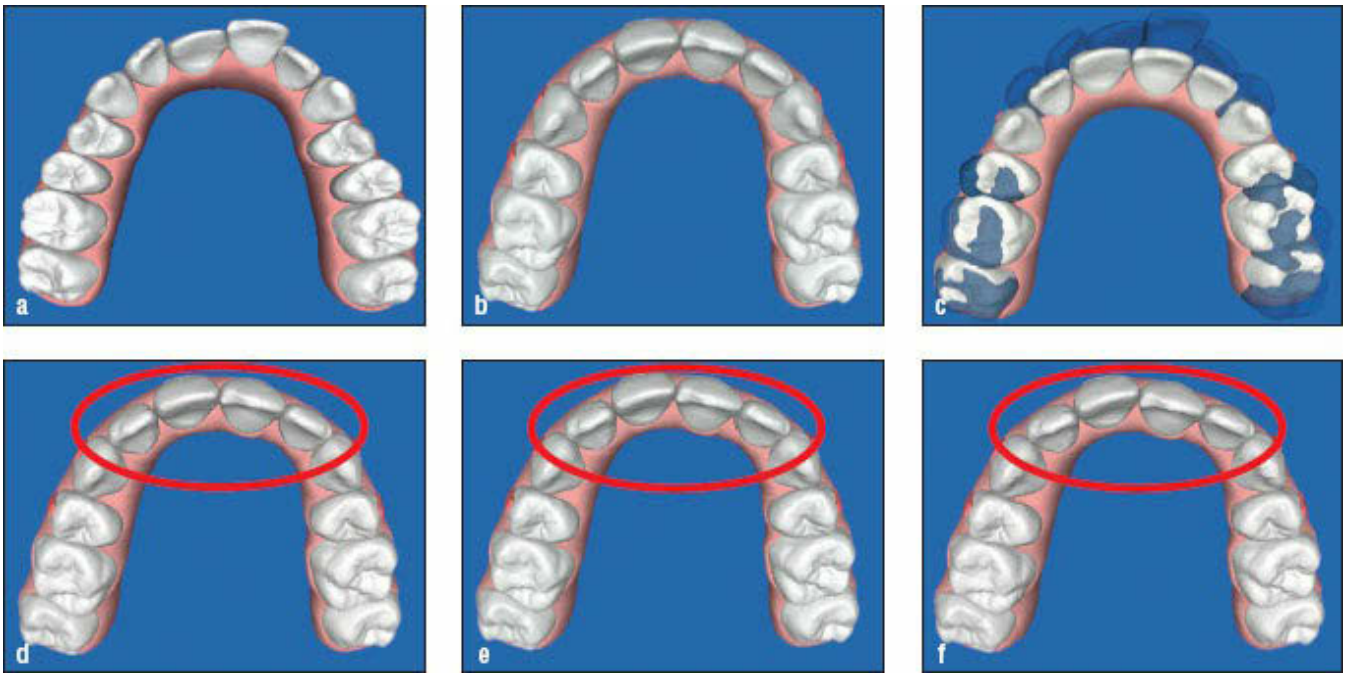


Fig 4-37 Before *(a)* and after *(b)* treatment with extraction of first premolars. Based on a superimposition of the initial position and presumed position at the end of treatment *(c)*, three overcorrections on the incisors *(d to f)* were prescribed to compensate for the risk of relapse of rotation on the maxillary right lateral incisor and tipping on the maxillary left central incisor.

Rather than initially prescribing hypothetical overcorrection, which may not be attainable at the end of treatment nor compatible with the projected ClinCheck, it is preferable to prescribe finishing (or refinement) measures based on a new impression taken during treatment with the last aligners. This approach often provides a superior result.

An example of overcorrection in a treatment plan that included extraction of the first premolars is shown in Fig 4-37.

12. Treatment preferences

Treatment preferences are recorded by the clinician on VIP by accessing “My Account,” “Doctor Profile,” “Treatment Preferences” (Fig 4-38). The clinician can use this feature to directly communicate treatment preferences as well as definitive treatment choices to Align Technology technicians, including:

- Expansion: How, how much, and where
- Overbite: Amount of reduction, level of the free edge of lateral incisors with regard to central incisors
- Overjet: Amount of reduction

- Extrusion: Use of attachments
- Posterior distalization, IPR, dental midline

With the current version of ClinCheck, new features that allow for enhanced clinical predictability are included (see also chapter 5):

- Optimized attachments for anterior extrusions and canine rotations
- Power ridges on incisors, which enable more effective lingual root torque
- Displacement velocity optimization designed for better controlled tooth movements
- IPR Staging Protocol Improvements. IPR performed later during treatment will result in less enamel removal

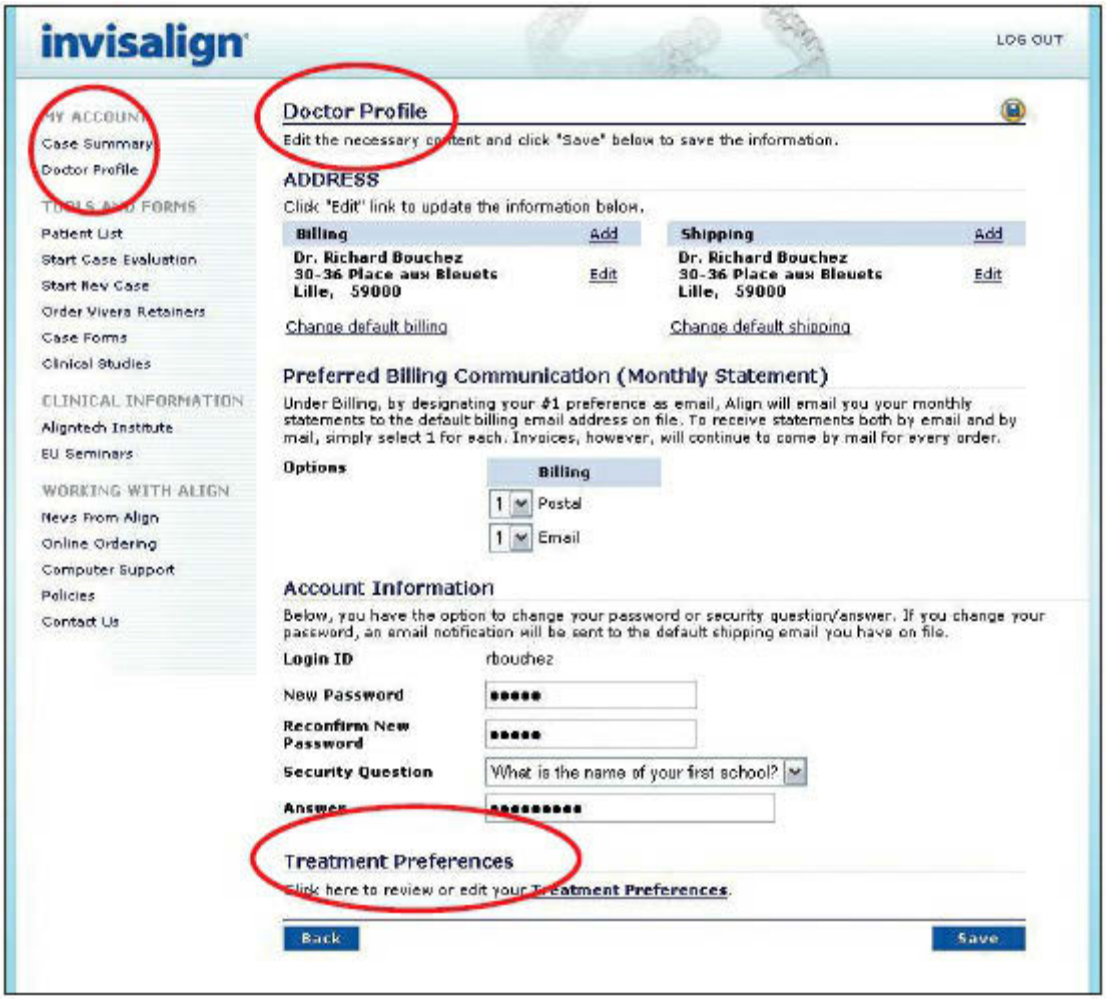


Fig 4-38 "Treatment Preferences" is accessed through the "Doctor Profile" under "My Account."

To allow these optimized attachments to work, automatic preferences for anterior treatment must be removed, otherwise the indicated preferences will be given priority.

13. ClinCheck objectives

“ClinCheck Objectives” is where the clinician may include extreme movements included in the treatment plan but are clinically impracticable using the Invisalign system alone. These movements, which can be achieved by an auxiliary treatment such as quad-helix, fixed appliances, or elastics, should be taken into account in order to create a precise final simulation of the planned treatment. The standard procedure will automatically eliminate these extreme movements from the simulation and may give a false or disappointing visual result. In this case, a selection must be made on “Perform less predictable movements to achieve a more ideal ClinCheck.”

To avoid this relatively unpredictable step, all overcorrections and extreme movements should be performed before PVS impression taking. The position can be maintained with a thermoformed retention splint on each treated arch while waiting for delivery of the aligners.

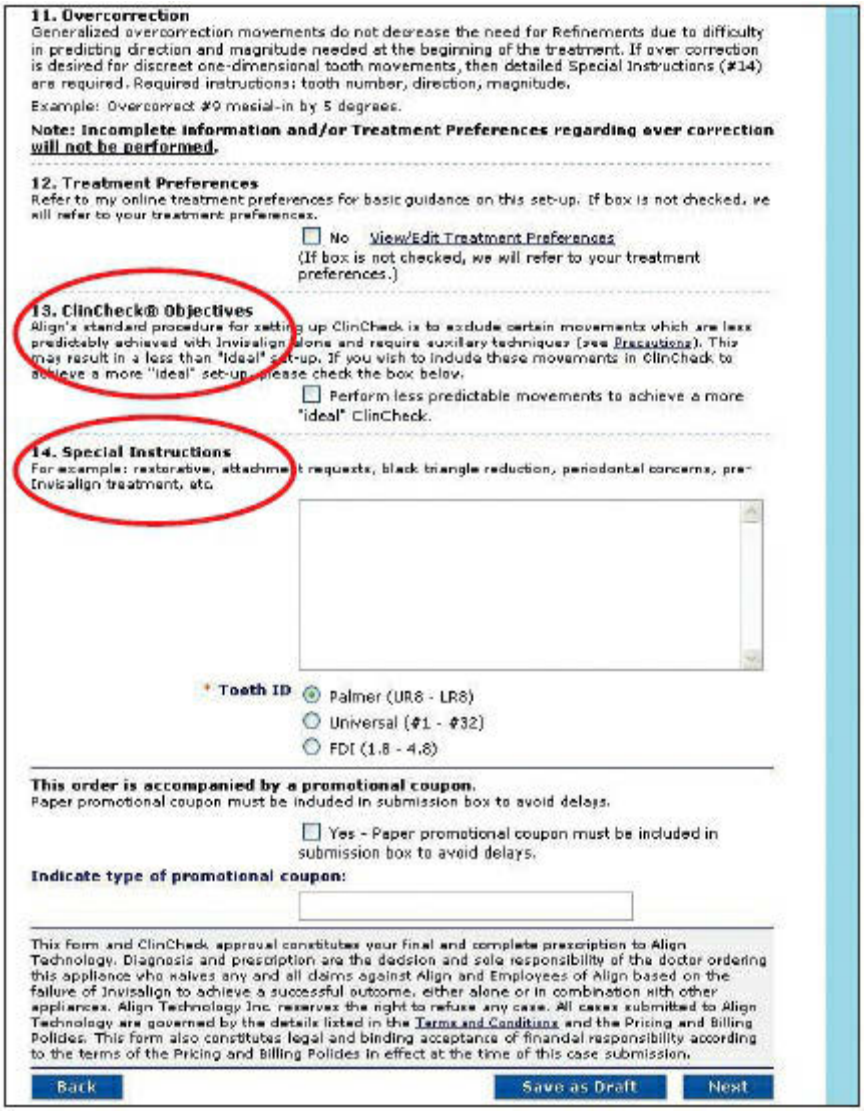


Fig 4-39 Prescription chart for ClinCheck objectives and special instructions.

14. Special instructions

The “Special Instructions” section (Fig 4-39) is essential. The dialog box will allow the clinician to directly and precisely communicate all special requests concerning the patient or the desired treatment to Align technicians.

Although the treatment plan is completely filled in on the online chart, writing general and particular requests in this section allows the technician to better understand the condition to be treated and the desired result. He or she can then better adhere to the envisaged treatment profile and simulate a correction suited to the clinician’s expectations.

A few extra minutes spent clearly writing the desired treatment in the dialog box will often save several days, even several weeks, that may

otherwise be spent waiting for modifications of the ClinCheck simulation caused by the technician's poor initial understanding of the treatment objectives.

Following is an example of a prescription that might be included in the "Special Instructions" section (Fig 4-40).

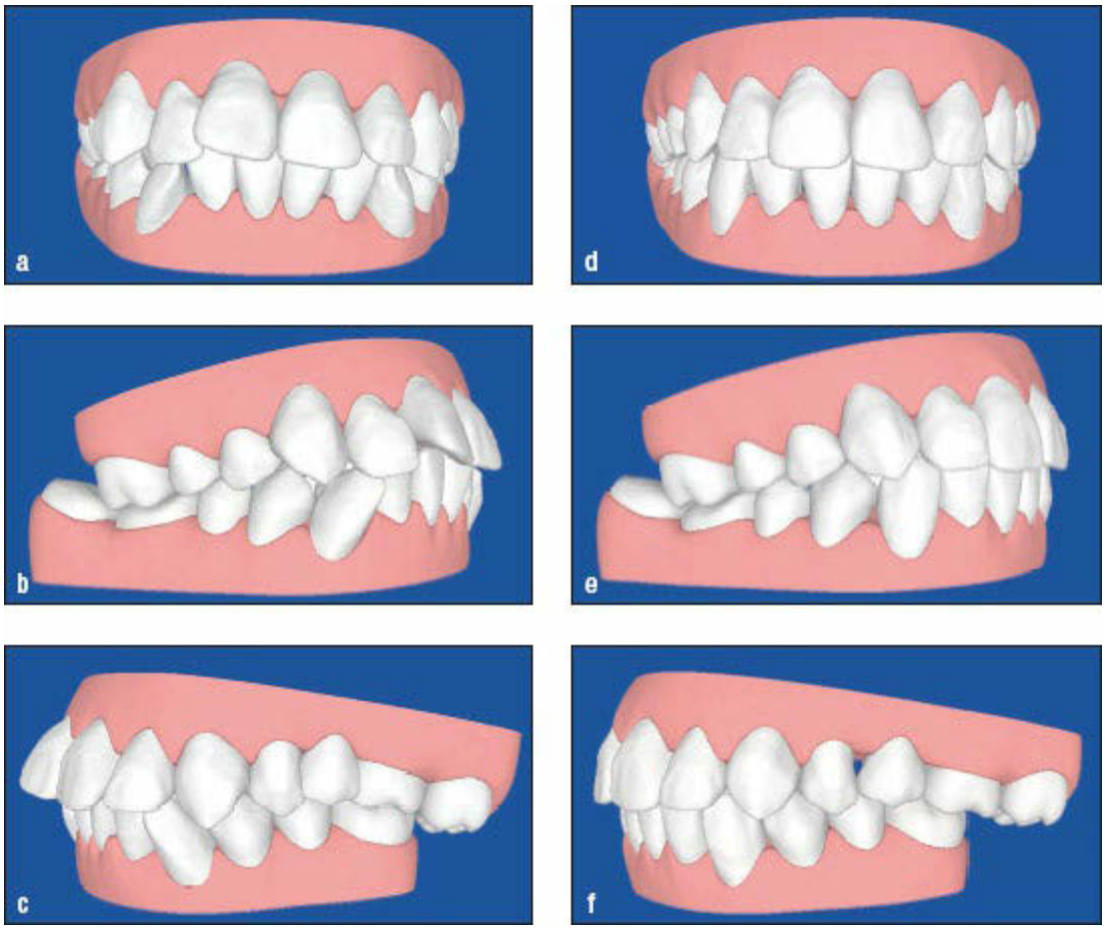


Fig 4-40 Before prescription *(a to c)*; simulation of the prescribed treatment *(d to f)*.

- In the maxilla, please create space for a future implant to replace the left second premolar, correct crowding by IPR, and correct the rotation of the left canine with a rectangular vertical attachment.
- In the mandible, please correct crowding by IPR, specifically between the right second premolar and first molar and between the right first molar and second molar, which are prostheses (reduction may be carried out up to 0.6 mm).
- At the end of the treatment (to avoid any interference with other movements), intrude the maxillary left second molar with horizontal rectangular attachments on the maxillary right and left first and second premolars to facilitate implant placement on the mandibular left second

molar. Thank you.

If using tooth numbers rather than tooth names, be sure to select the appropriate nomenclature type (“Tooth ID”) below the “Special Instructions” window (see Fig 4-39).

Fig 4-41 Photographs and radiographs in composite layout.

Submitting patient images

The procedure for submitting patient images is described in detail in chapter

3. It is strongly advised to submit a composite photo to save time (Fig 4-41). To further facilitate the process, photos should be initially prepared by a dental assistant and recorded under the patient's name in a folder called, eg, "Invisalign-framed patient photos." This allows the clinician to rapidly retrieve on the screen, from the online VIP office, a complete board of extra- and intraoral photos of the patient (including photos showing occlusion recorded with an articulating paper) (Fig 4-42). The clinician can consult this information anywhere and at any time without having to access photo management or storage software at the clinic.

Fig 4-42a Online information recorded on VIP.

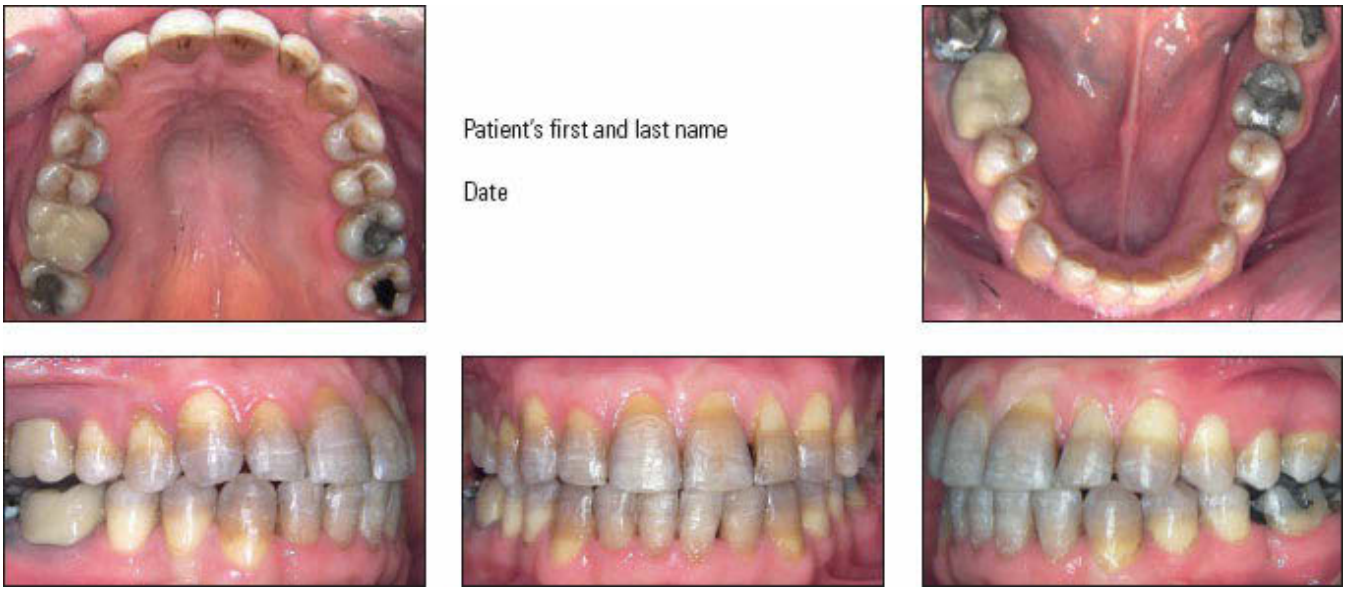


Fig 4-42b End of treatment after surgery (29 months).

Moreover, although online submission of radiographs is not compulsory for ClinCheck setup, it is also advised to upload dental panoramic and lateral cephalometric radiographs (see Fig 4-41), thus providing rapid consultation when needed.

Fig 4-43a Summary of treatment prescription.

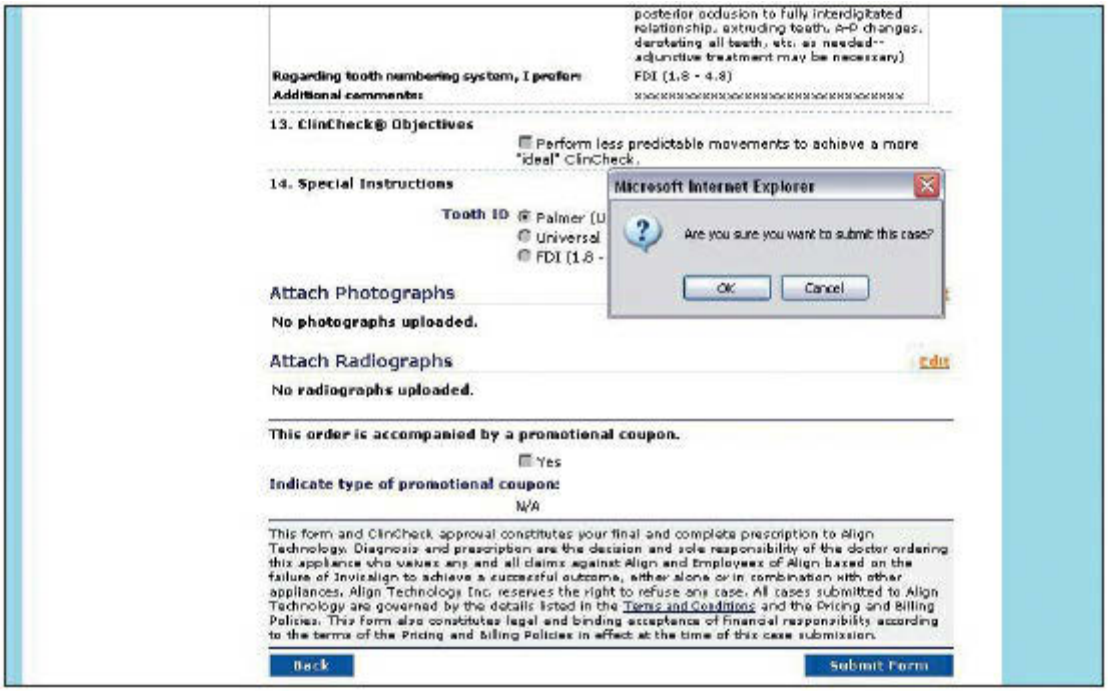


Fig 4-43b Clinician's definitive agreement to case submission.

Treatment summary

Review your prescription summary before submitting your definitive treatment plan (Fig 4-43a). When you are satisfied that everything is correct, press "Submit Form," then when prompted by the window "Are you sure you want to submit this case?" press "OK" (Fig 4-43b).

Treatment Strategies

5

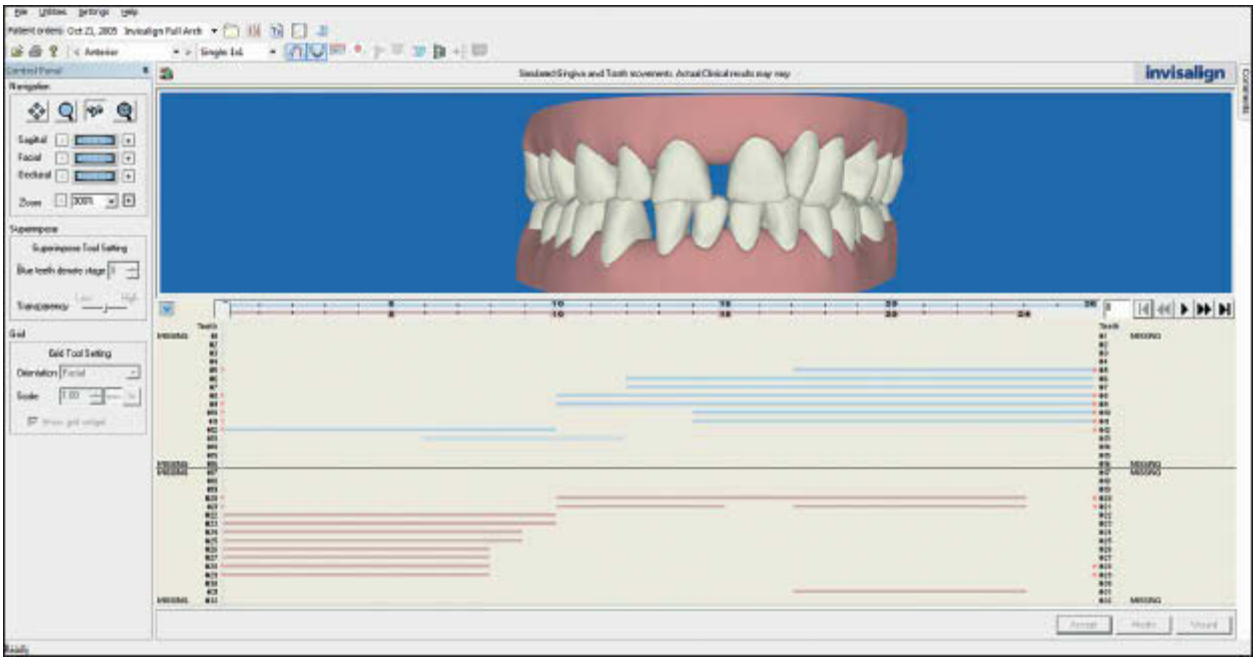


Fig 5-1a View of the details of a single treatment stage.

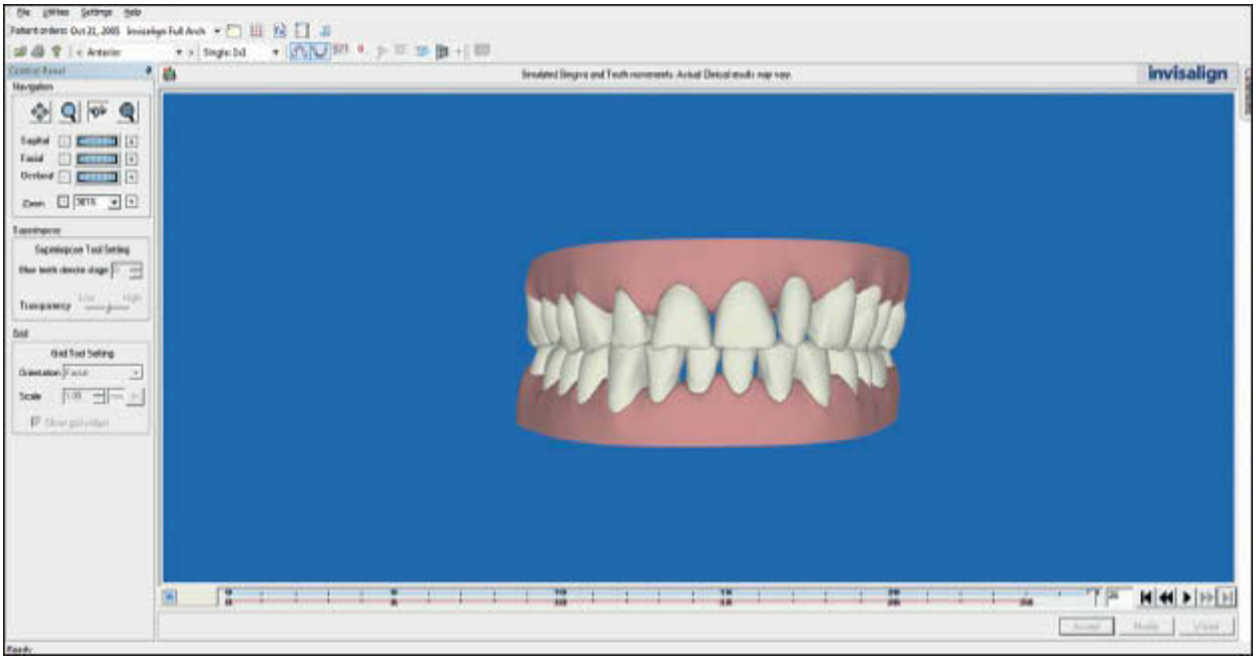
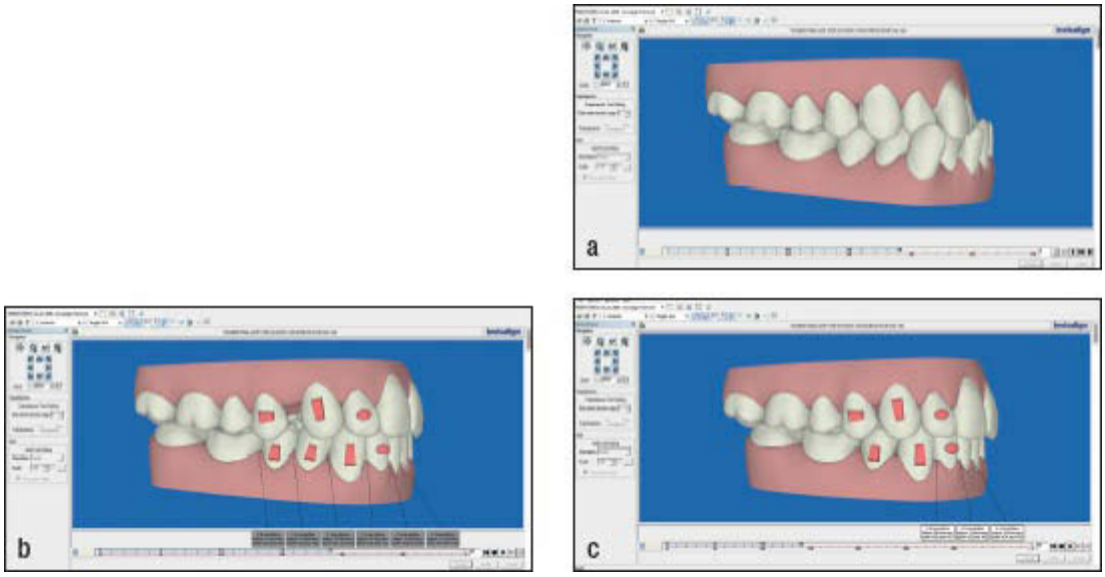


Fig 5-1b View of overall results of treatment.

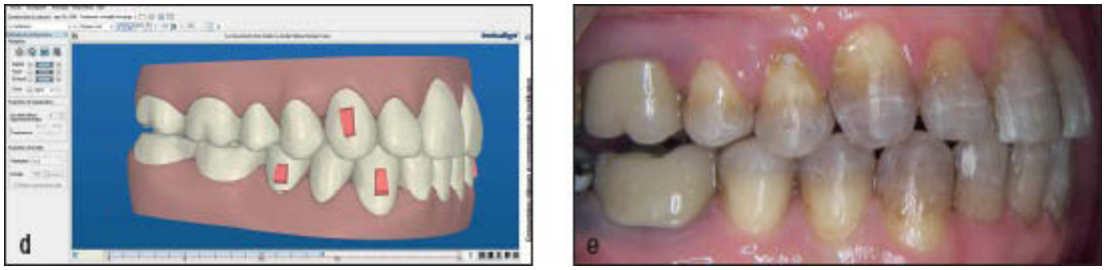
ClinCheck 2.9 is the latest version of 3D treatment planning software by Align Technology. Its new interface, based on Windows (Microsoft), is easier to use and has new features. The process of adding comments and requesting modifications has been improved and simplified. ClinCheck setup files are stored in the clinician's computer, allowing them to be used offline with an improved local patient database viewer. New features that enhance

clinical predictability are also included (see page 72).

New tools for viewing detailed simulated treatment stages allow the clinician to see tooth movements at each treatment stage (Fig 5-1a) or from a global perspective (Fig 5-1b).



Figs 5-2a to 5-2c *(a)* Simulation of the initial situation: Class III occlusion. *(b)* Simulated treatment results without extraction. *(c)* Simulated treatment results with extraction of both mandibular first premolars.



Figs 5-2d and 5-2e End of treatment after surgery.

Another helpful feature is that several ClinCheck setup files can be open simultaneously, allowing a comparison of various treatment options or the same treatment among different patients. Figure 5-2 shows an example of simulated treatment of a Class III occlusion (Fig 5-2a) without extraction (Fig 5-2b) and with extraction (Fig 5-2c). In this case, the treatment simulation without extraction shows that this option is clearly impracticable because:

- The maxillary anterior segment clinically and biologically cannot be advanced very far, and the space between the right canine and first premolar is undesirable.

- The required mandibular interproximal reduction (IPR) (0.5 mm per tooth in five teeth) is too much to be feasible.
- The number of attachments is too high.
- Without extraction, 19 stages are required in the maxillary arch; with extraction, only 14 stages are required.

The final choice is then between extraction of the mandibular first premolars to establish a Class I canine and therapeutic Class III molar relationship at the end of treatment (see Figs 5-2c to 5-2e) or orthosurgical treatment. A new simulation showing the stages and results anticipated with a surgical treatment option can be requested and compared with the extraction simulation.

The treatment strategy applied in ClinCheck will depend on your instructions to the technician regarding how to control:

- Tooth movements—by oval, rectangular, or beveled attachments
- Available space—by IPR, arch expansion, or extraction
- Anchorage—with maxillomandibular elastic traction or mini-implants

Table 5-1 ClinCheck default attachments according to type of movement*

Type of movement		Default attachment type*	
		Automatic	Clinician may request
Rotation	Canine	Optimized attachment (droplet shape) (Enhanced clinical predictability feature)	
	Premolar	Vertical rectangular attachment: variable length, 1-mm thickness	
Extrusion		Beveled horizontal rectangular optimized attachment (Enhanced clinical predictability feature)	Horizontal ellipsoidal attachment of .75-mm thickness
Uprighting of the root axis			None or vertical rectangular attachment of variable height and 1-mm thickness
Extractions	Incisor	Vertical rectangular attachment on each of the two teeth adjacent to the extraction site	
	Premolar	Vertical rectangular attachment on canine, remaining premolar, and first molar	
Intrusions	Anchorage	Horizontal beveled attachment on first premolars	
	Anchorage if premolar is also in rotation	Vertical rectangular attachment of variable height and 1-mm thickness on each premolar	
Retention, anchorage, distalization, torque, others			No attachment will be placed without the clinician's special request

*Default attachments are used unless the clinician asks for changes in "Treatment Preferences" or when modifying a ClinCheck simulation.

Control of Tooth Movements: Attachment Types and Indications

In the ClinCheck program, certain attachments will be placed by default depending on the clinical situation (Table 5-1), but the final choice regarding attachment type, position, and timing of placement and removal is up to the clinician's judgment. The prescription of attachments may be done during treatment prescription in the section "Treatment Preferences," online

reviewing, or modifications of ClinCheck.

Various types of attachments are available and can be made in the mouth with lightcured fluid composite placed in an aligner called the *template* (Figs 5-3a and 5-3b). This prefabricated polycarbonate template (Fig 5-3c) is available in different shapes, including ellipsoidal or rectangular, and serves as a mold for fabrication and positioning of the selected attachment (Fig 5-3d). Using a cotton pliers (Fig 5-3e) to apply pressure mesial and distal to the attachment location on the template (Fig 5-3f) is recommended to avoid making the composite too thick (Fig 5-3g). A small hole can also be drilled at the bottom of the template so that the excess material can be released through the hole. It is strongly advised to select a composite color matched with a shade guide to the patient's tooth color so that the attachment is as invisible as possible.

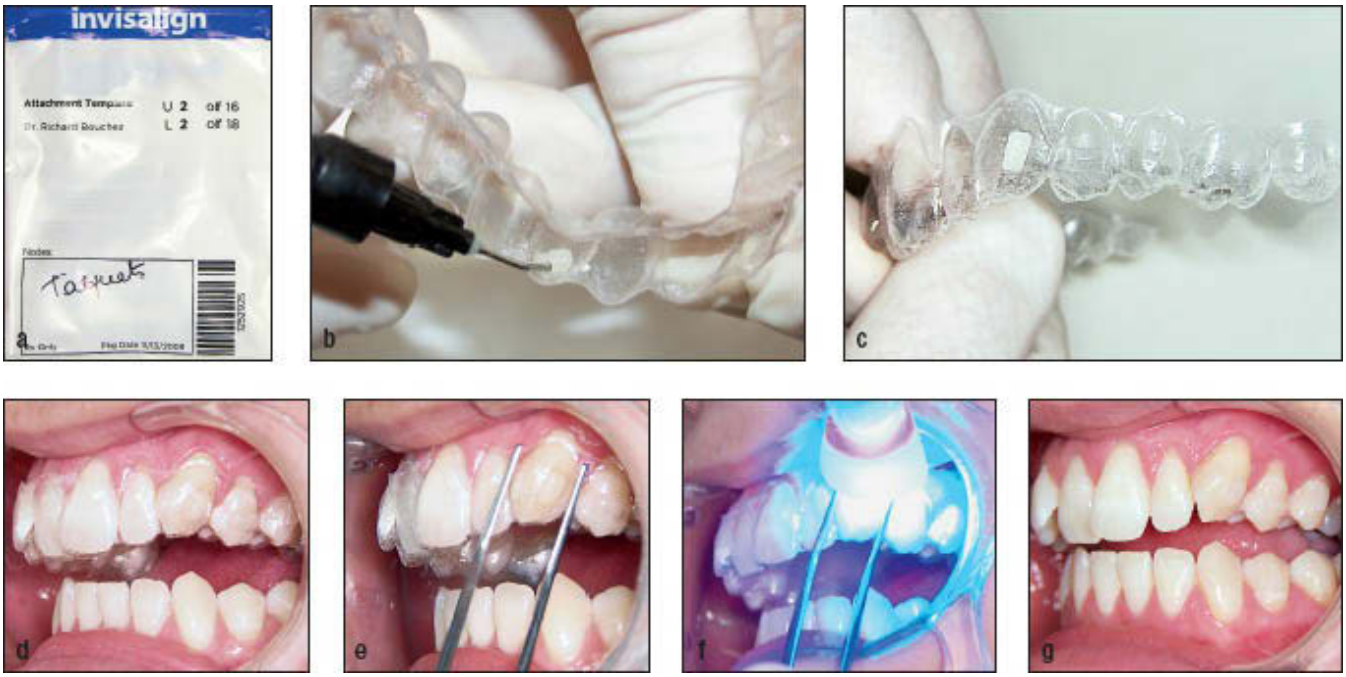


Fig 5-3 *(a to g)* Bonding of attachments.

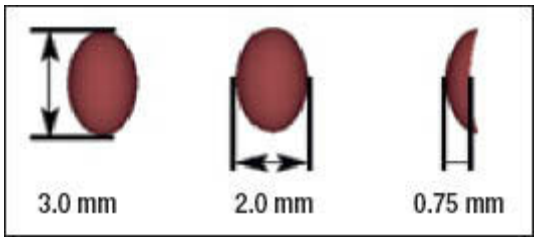


Fig 5-4 Ellipsoidal attachments. Height: 3.0 mm; width: 2.0 mm; thickness: 0.75 mm.

The following materials are recommended for secure bonding of attachments:

- Tetric Evoflow composite (Ivoclar Vivadent). Contains three types of nanoparticles (nanofillers, nano-color pigments, and nanomodifiers). This material's optimal flow prevents bubbles from forming under the bonded attachment. The material possesses sufficient consistency and can be placed in small cavities with the surface affinity ensured by the nanomodifiers, improved shade due to nano-color pigments, and radiopacity.
- G-Bond self-etching adhesive (GC Coporation)

Ellipsoidal attachments

Ellipsoidal attachments (Fig 5-4) were the first type used for Invisalign treatment.

Indications:

- Tooth extrusions (default option: horizontal)
- Aligner retention (default option: vertical)

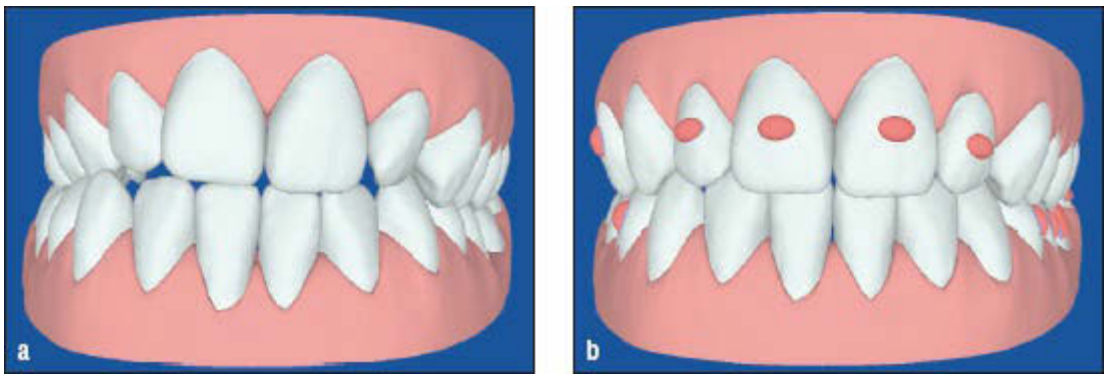


Fig 5-5 Use of ellipsoidal attachments for extrusion of anterior teeth to close an open bite (horizontal attachments on maxillary incisors) and for aligner retention (vertical attachments on posterior teeth). *(a)* Initial situation. *(b)* After simulated treatment.

Fig 5-6 Example of maxillomandibular extrusion. *(a)* Open bite requiring extrusion of maxillary and mandibular anterior segments. *(b)* After simulated treatment. *(c)* Clinical view before treatment. *(d)* Treatment in progress (stage 13 of 22): Closure of the maxillary open bite, extrusion of the maxillary incisors, and tooth alignment have been achieved. Attachments have been placed on the mandibular anterior segment to continue closure of the open bite. *(e)* After actual treatment.

Tooth extrusions

Because their shape is more discreet than that of rectangular attachments, ellipsoidal attachments are recommended on incisors for treatment of anterior open bite (Figs 5-5 and 5-6). They also make removal of aligners easier when several attachments are needed.

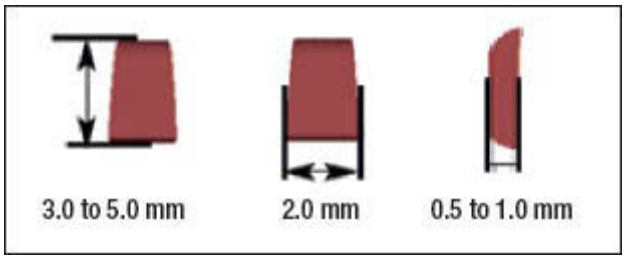


Fig 5-7 Rectangular attachments. Height: 3.0 to 5.0 mm; width: 2.0 mm; thickness: 0.5 to 1.0 mm.

Fig 5-8 *(a to c)* Rotation of the mandibular left second premolar with classic elastic traction.

Aligner retention

Vertical ellipsoidal attachments are used to increase the aligner's retention in the mouth (see Fig 5-5). They are generally placed by default on first premolars.

In the case of extreme open bites, no attachments are prescribed, and surgery is planned to correct the malocclusion.

Rectangular attachments

The more recently developed rectangular attachments (Fig 5-7) are available in three types: vertical, horizontal, and beveled. The clinician must specify the type of rectangular attachment desired.

Vertical rectangular attachments

Indications:

- Tooth rotations
- Extractions
- Axis control

Tooth rotations

To rotate canines and premolars, especially mandibular second premolars, which are generally round, attachment placement is essential to ensure precise rotation during treatment. Certain difficult rotations will initially require correction using classic elastic traction (Fig 5-8).

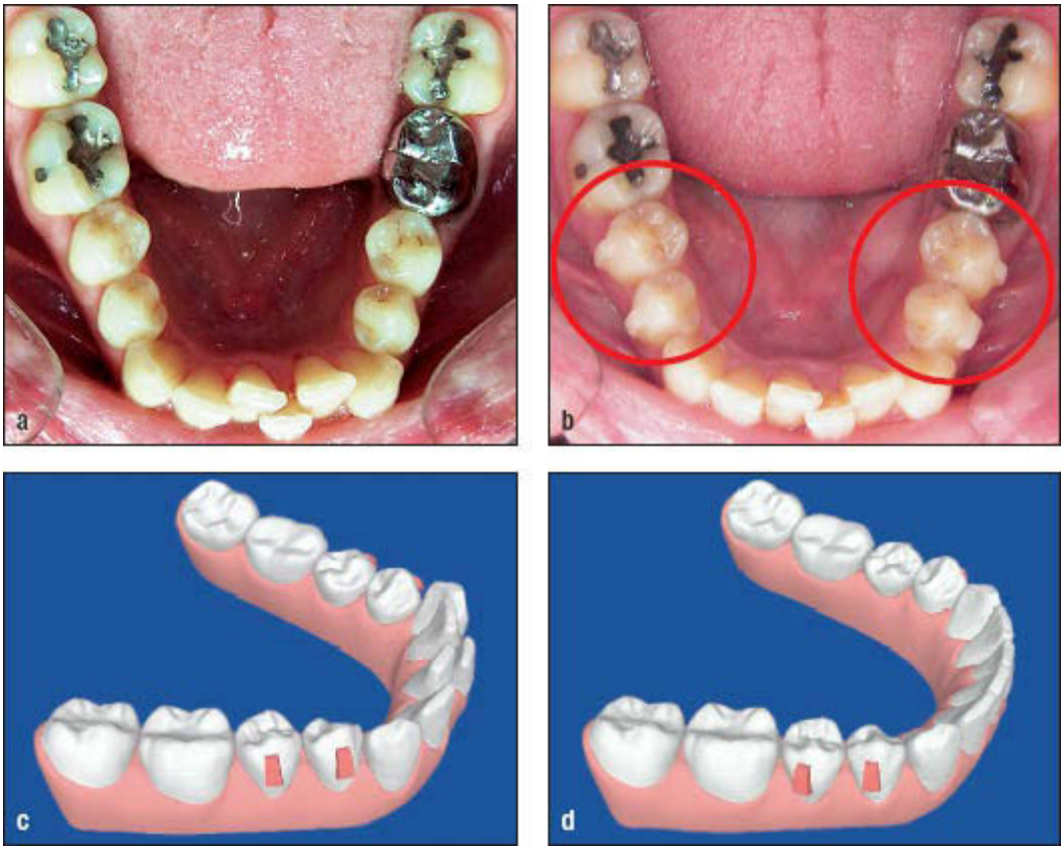


Fig 5-9 Correction of rotation with vertical rectangular attachments on the mandibular premolars. *(a)* Occlusal view before treatment. *(b)* Occlusal view after placement of attachments. *(c)* ClinCheck simulation before treatment. *(d)* Simulated results of treatment. Note the uprighting of the premolars.

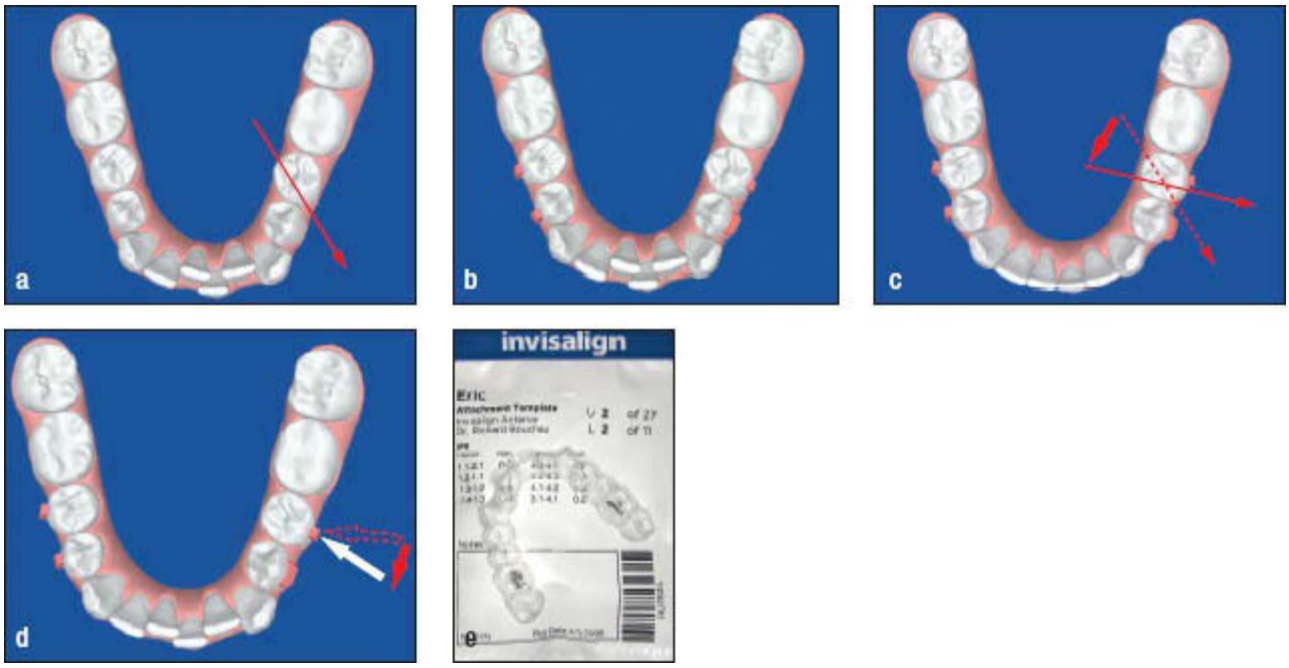


Fig 5-10 The attachment on the mandibular right second premolar was moved between stages 13 and 14 to allow complete rotation correction. *(a)* Before treatment. *(b)* Placement of attachments. *(c)* Stage 13: The original placement of the attachment is no longer effective for obtaining the desired rotation. *(d)* Stage 14: The attachment is moved. *(e)* A template aligner is provided by Invisalign for both stages at which attachments will be fabricated (in this case, stages 2 and 14) so that attachments will be placed accurately and in accordance with the planned treatment.

A case in which rotation correction was carried out using vertical rectangular attachments is shown in Fig 5-9.

In case of significant rotation, the location of attachments on the tooth can be changed during the course of treatment to ensure precise rotation (Fig 5-10).

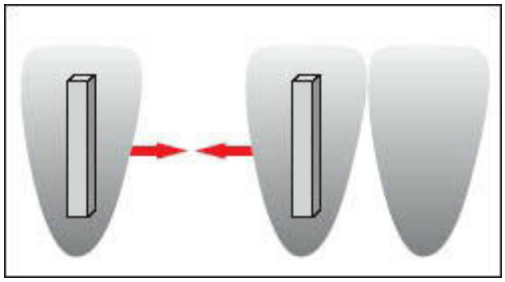


Fig 5-11 Two vertical attachments are needed for the extraction of an incisor: one on each adjacent tooth.

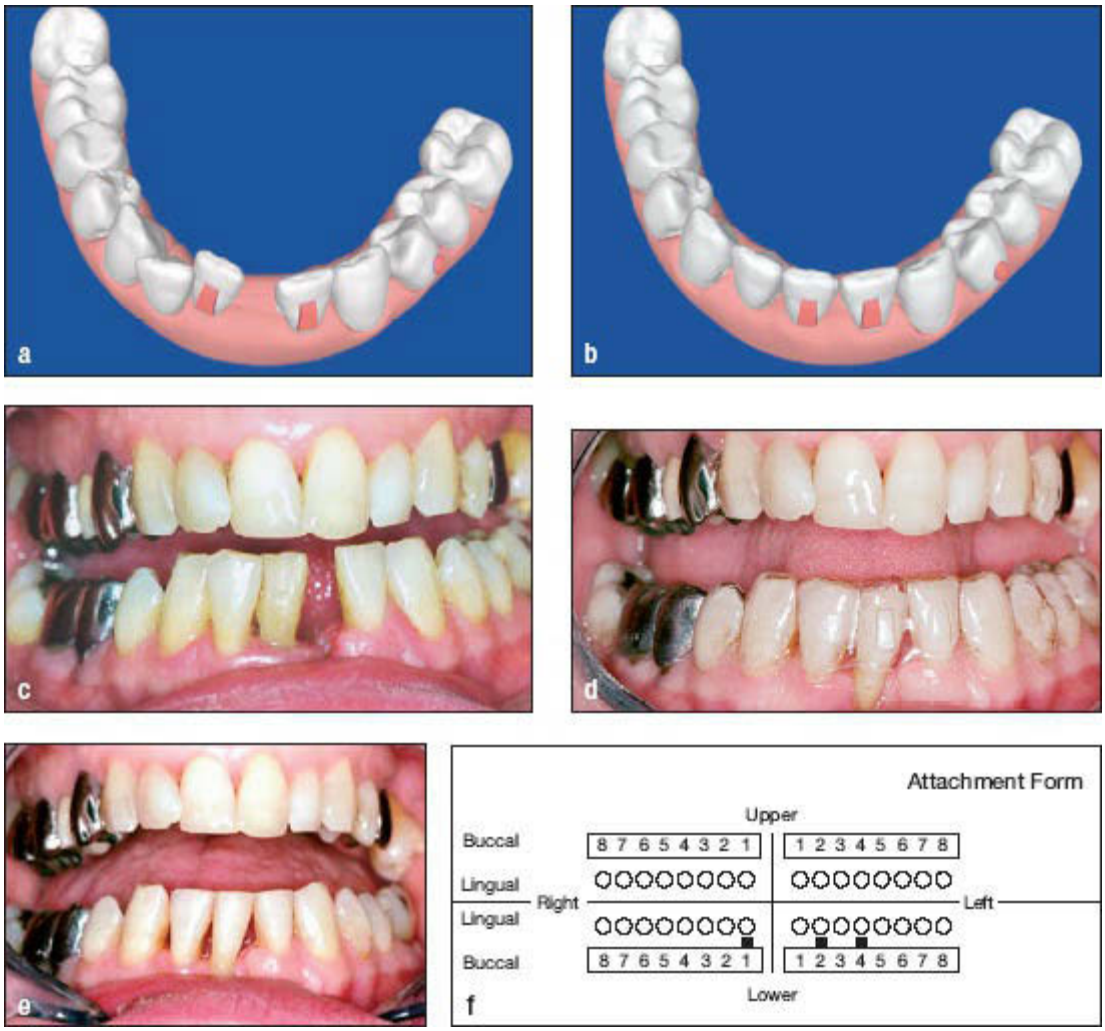


Fig 5-12 *(a)* ClinCheck simulation at the beginning of treatment to close a space following extraction of the mandibular left central incisor due to severe periodontitis. *(b)* ClinCheck simulation of the treatment results. *(c)* Clinical view before treatment. *(d)* Near the end of treatment, attachments in place. *(e)* Definitive results of treatment (48 maxillary and 37 mandibular aligners), attachments removed. (Retention by S. Gonthier.) *(f)* Placement of attachments is indicated on a Virtual Invisalign Practice (VIP) chart.

Extractions

Attachments are placed on each tooth adjacent to the extraction site (Fig 5-11).

An example of closure of a space due to the loss of a mandibular central incisor resulting from severe periodontitis is shown in Fig 5-12. Three vertical attachments are needed for the extraction of a premolar: one on the canine, one on the remaining premolar, and one on the first molar (Fig 5-13).

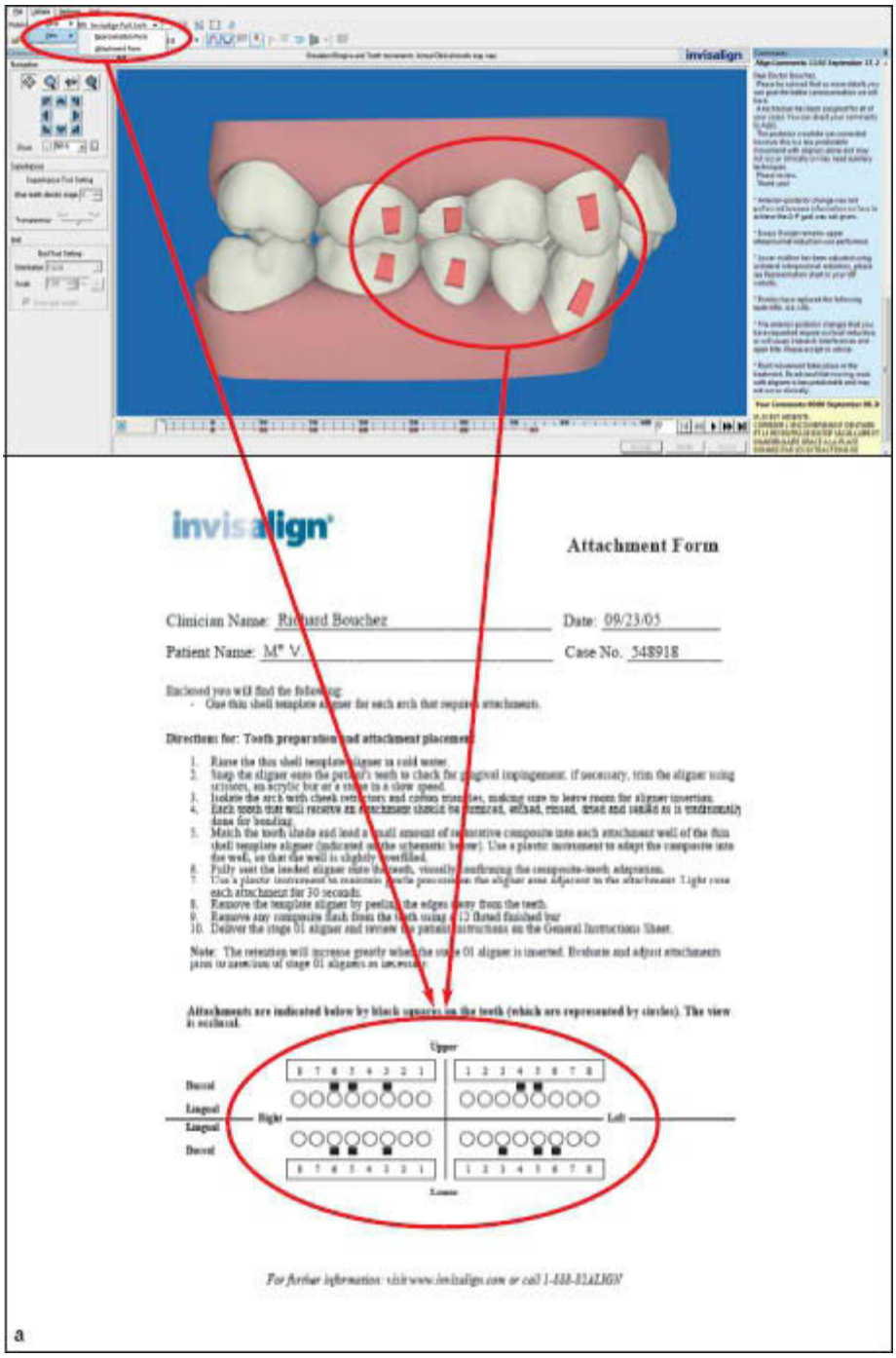
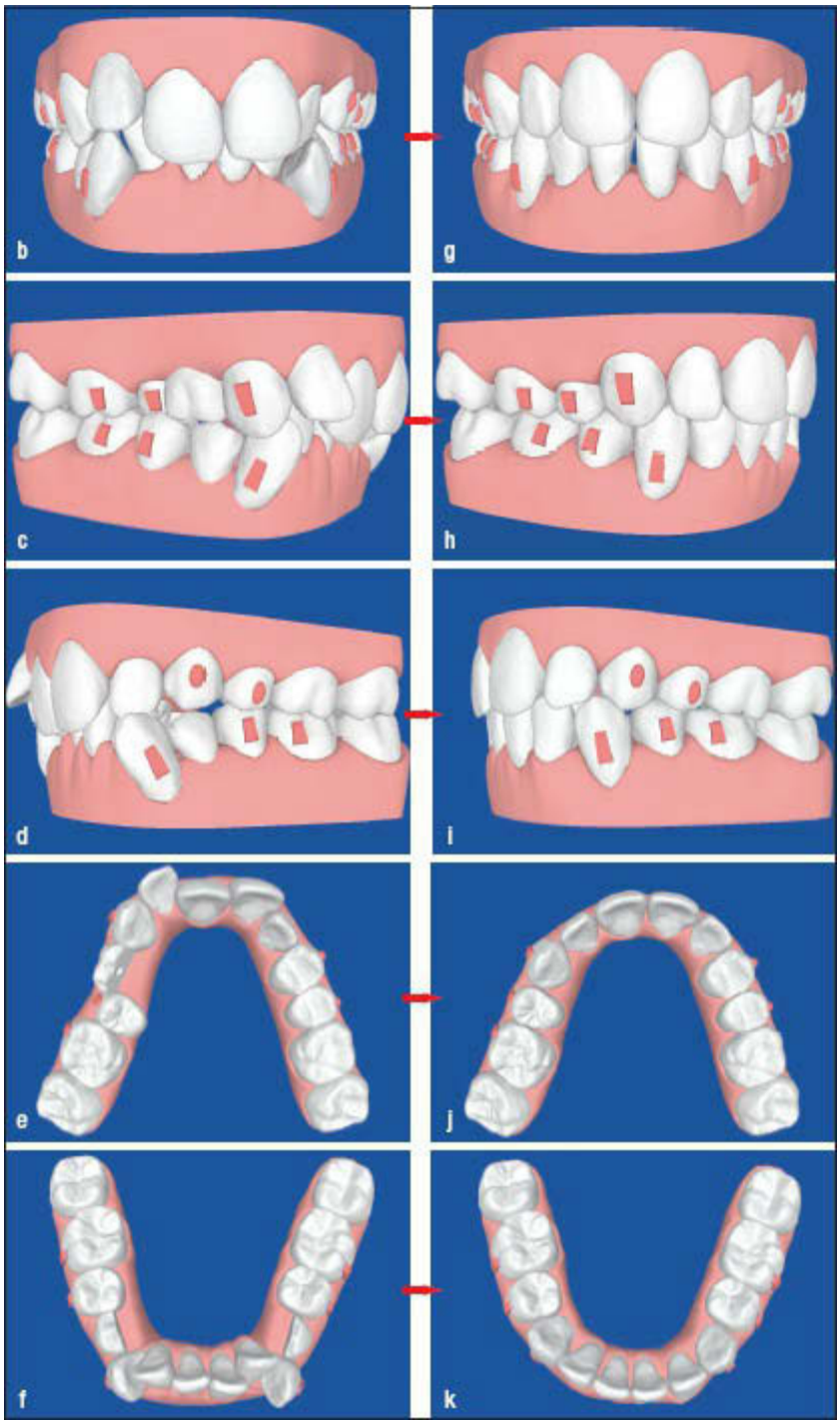


Fig 5-13a Attachment form in VIP for a case involving extraction of three premolars (maxillary right and both mandibular). Unfortunately, the maxillary left canine had already been removed.



Figs 5-13b to 5-13k *(b to f)* Simulated views before treatment. *(g to k)* Simulated views after treatment, including extraction of three premolars.

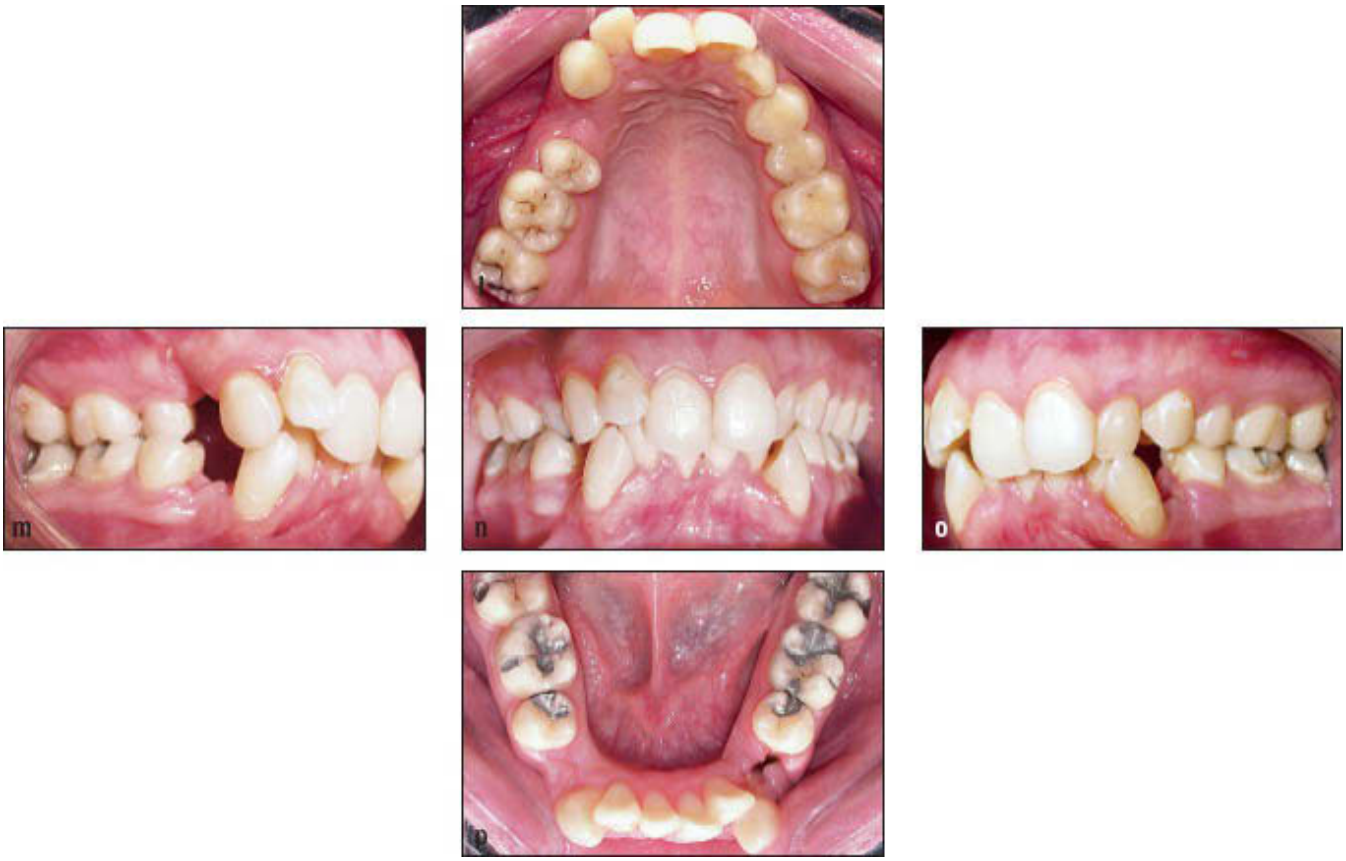


Fig 5-13 *(l to p)* Clinical views before treatment.

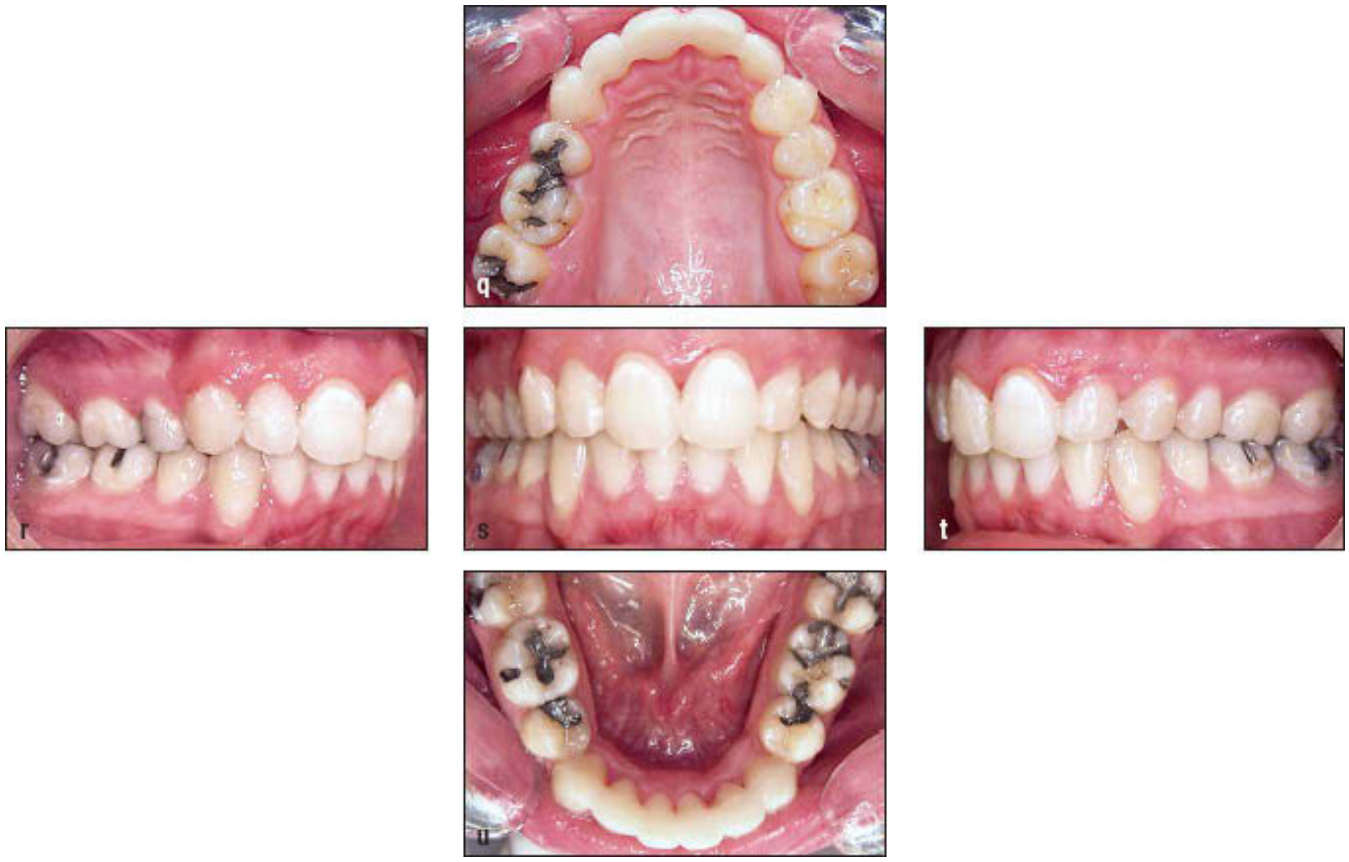


Fig 5-13 *(q to u)* Clinical views after treatment with 48 maxillary aligners and 37 mandibular aligners.

Fig 5-14 Axis control of anterior teeth.

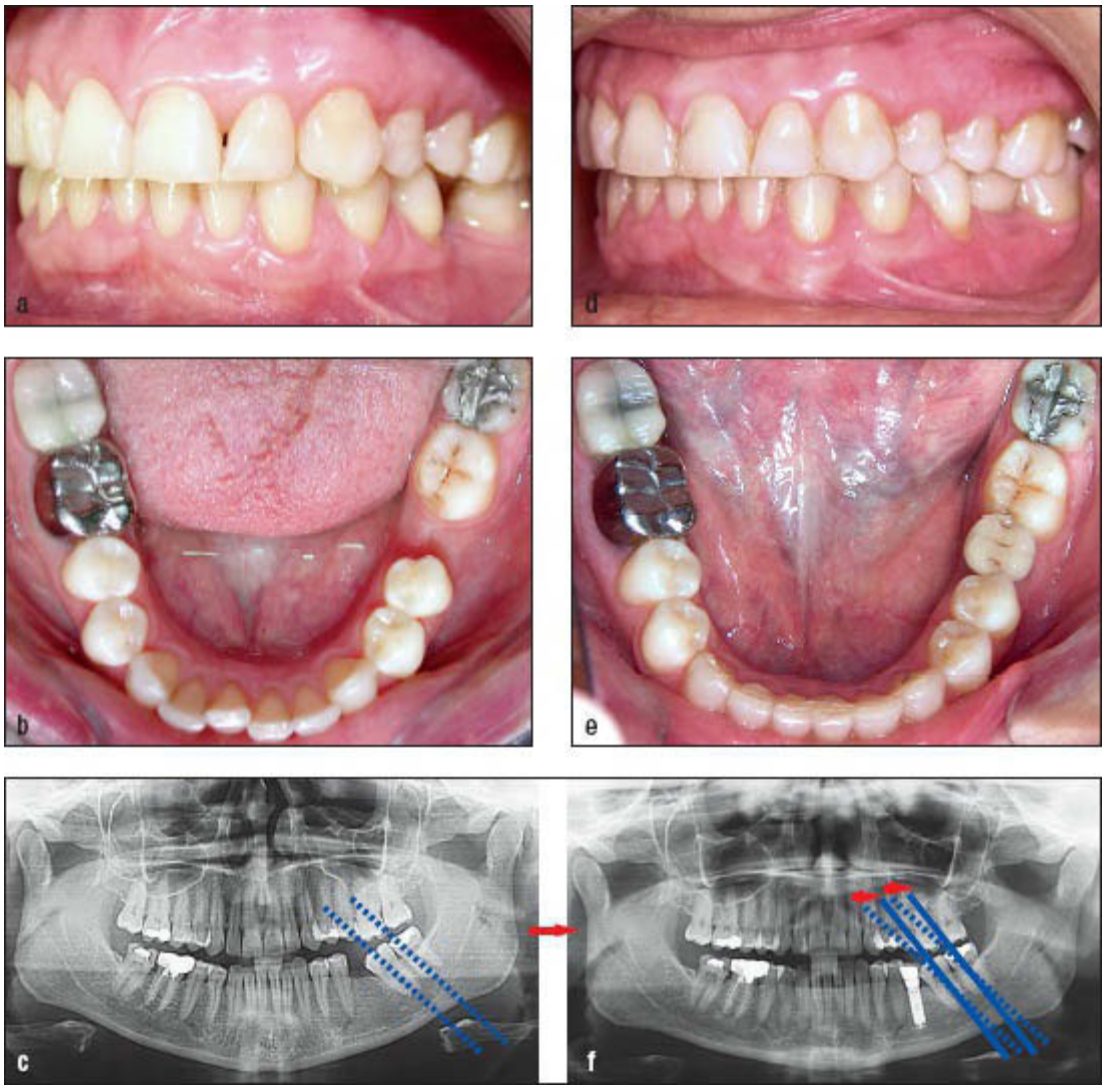


Fig 5-15 Treatment to upright molar axes before *(a to c)* and after *(d to f)* implant and prosthesis placement. (Implant placement by P. Lambert.)

Axis control

Vertical rectangular attachments are used for axis control of anterior teeth (Fig 5-14) as well as to upright the axes of posterior teeth, eg, after tooth extraction without replacement and resultant mesial tipping of the posterior teeth or in preparation for prosthesis or implant sites (Fig 5-15).

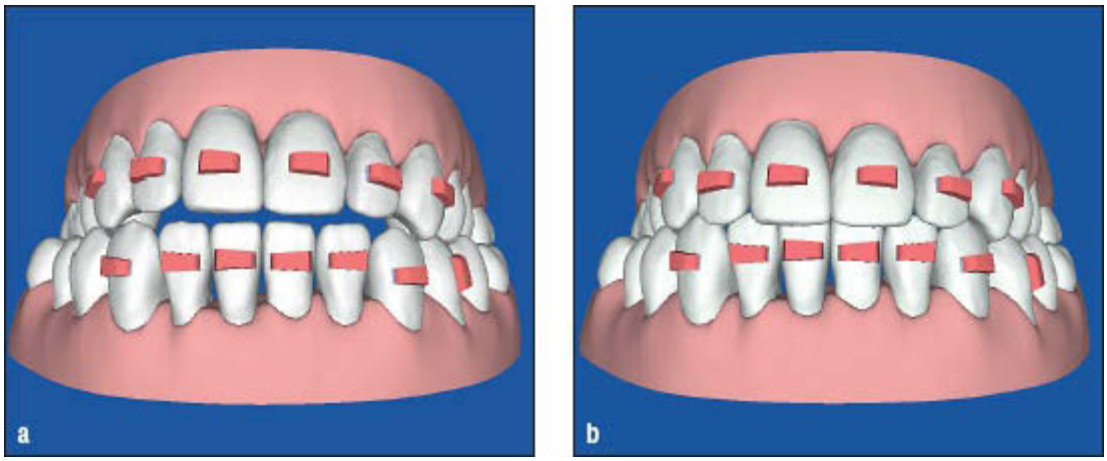


Fig 5-16 Treatment of anterior open bite. ClinCheck before *(a)* and after *(b)* extrusion of the anterior segments with multiple horizontal rectangular attachments.

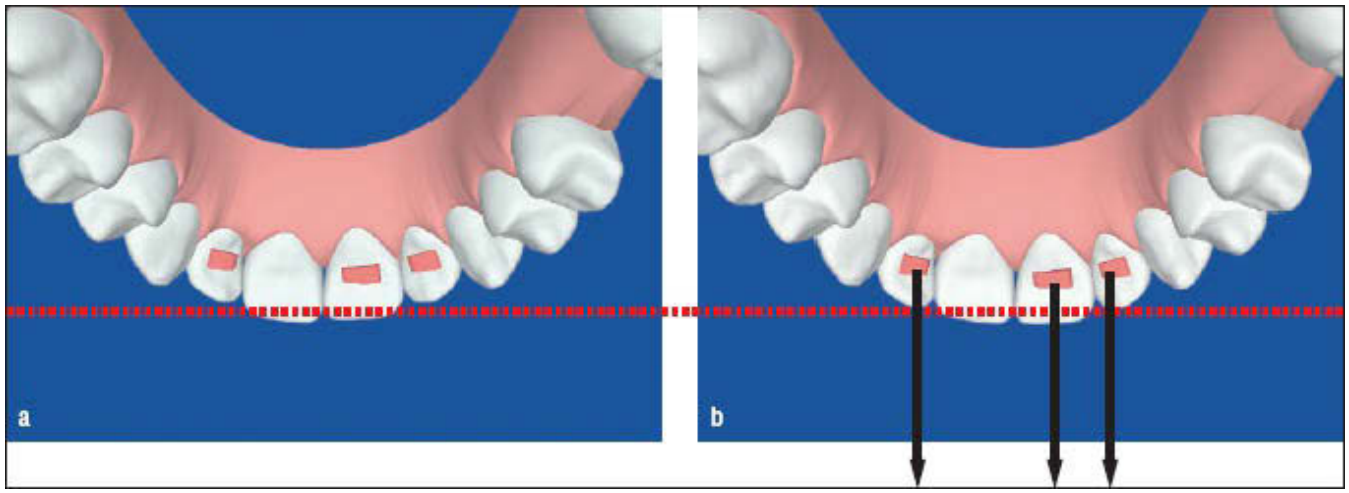


Fig 5-17 Horizontal rectangular attachments positioned lingually for the extrusion of the maxillary central and left lateral incisors, at the beginning *(a)* and the end *(b)* of treatment.

Horizontal rectangular attachments

Indications:

- Dental intrusions and extrusions
- Aligner retention

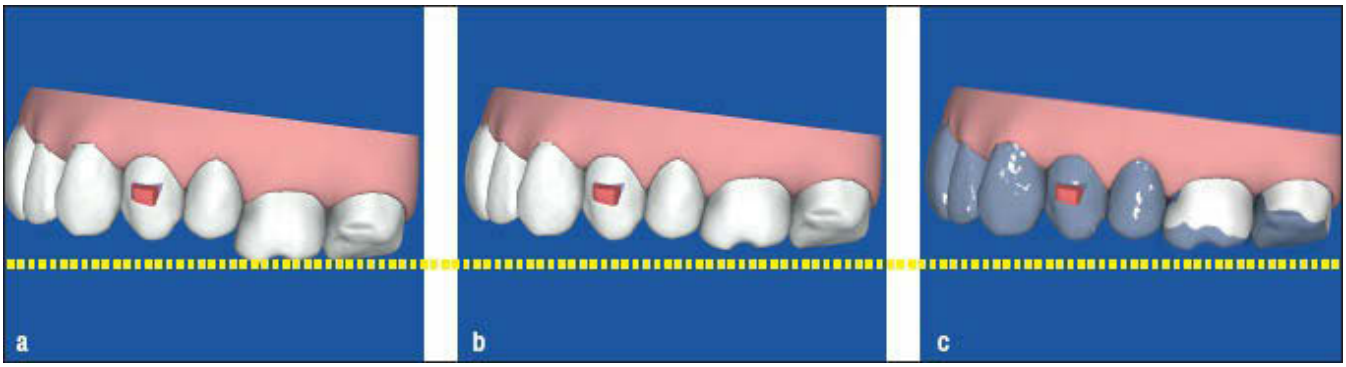
Dental intrusions and extrusions

Horizontal rectangular attachments are used on:

- Maxillary and mandibular premolars to intrude incisors. These attachments provide effective retention of the aligner on the teeth, avoiding removal of

the aligner due to the impact of intrusion.

- Incisors to be extruded (Fig 5-16); otherwise, the aligner will slide on the smooth surface of the incisors, and an unesthetic space may appear between the aligner's inner surface and the free edge of the incisors. Attachments may also be placed lingually for improved esthetics (Fig 5-17).



Figs 5-18a to 5-18c Treatment of an extruded first molar. ClinCheck before *(a)* and after *(b)* intrusion with a horizontal rectangular attachment and a superimposition of the expected movements *(c)*.

Figs 5-18d to 5-18f Teen treatment with rectangular horizontal attachments to anchor the aligner and interarch elastics for class II, division 2 correction.

Fig 5-19 *(a and b)* Single molar intrusion by elastic traction anchored on a mini-implant. (Surgery by Y. Dislaire.)

- Teeth on either side of the tooth requiring intrusion or extrusion (notably for prosthetic purposes) (Figs 5-18a to 5-18c).

- Maxillary and mandibular premolars when elastics are used for class II or class III correction. This improves the retention and avoids loosening of the aligner via tension created in the elastics during mouth opening (Figs 5-18d to 5-18f).

Since the intrusion of molars is sometimes difficult, the use of mini-implants and elastic traction before treatment with aligners can serve as a valuable adjunct to treatment (Fig 5-19).

Aligner retention

In certain patients with short teeth, a hypodivergent facial pattern (deep bite), or restored teeth that leave less surface area for bonding, horizontal rectangular attachments can be placed to assure retention of the aligner.

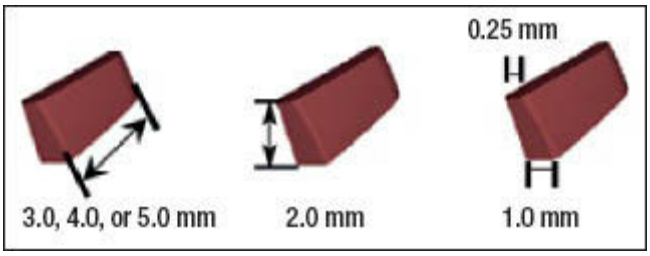


Fig 5-20 Beveled rectangular attachments. Height: 3.0 to 5.0 mm; width: 2.0 mm; thickness: 0.25 to 1.0 mm.

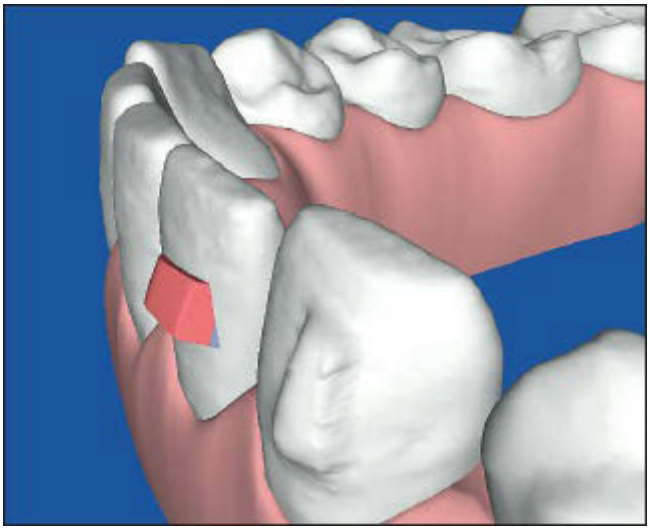


Fig 5-21a In cases of incisor deep overbite, a beveled rectangular attachment can help avoid occlusal interferences.

Beveled rectangular attachments

Indications: Retention of aligner (anchorage for intrusion)

For the same reasons previously described, in cases with deep overbite, beveled attachments (Fig 5-20) can be used to avoid occlusal interferences that could possibly lead to prematurely worn out or debonded attachments.

These attachments are very useful on mandibular incisors in cases with deep overbite (Class II, division 2) (Fig 5-21a). They also facilitate removal of the aligner by the patient.

Optimized Attachments: ClinCheck and Enhanced Clinical Predictability

Attachments for incisor extrusions and canine rotations

These attachments (Fig 5-21b) are designed based on a tooth's width, length, and shape. They are uniquely adapted to each tooth and improve the following movements:

- Extrusion of incisors and canines (beveled attachments)
- Rotation of canines (droplet-shaped attachments)

Beveled attachments

Beveled optimized attachments (Fig 5-21c) are used for the extrusion of incisors. When using beveled optimized attachments, the following parameters should be followed:

- Apply gentle force (0.2 to 1.0 Nm)
- Use for extrusions that are a minimum of 0.5 mm and a maximum of 2.5 mm

Fig 5-21b Attachments for incisor extrusions and canine rotations.

Fig 5-21c Beveled optimized attachments.

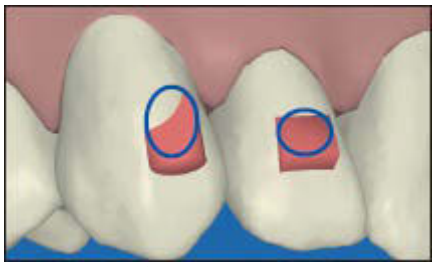


Fig 5-21d Active surface area *(indicated by blue ovals)*.

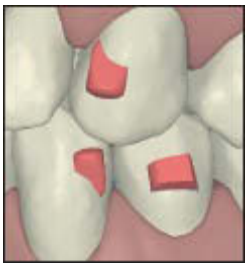


Fig 5-21e Optimized attachments for canine rotations (dropletshaped).

Fig 5-21f Before treatment.

Fig 5-21g After treatment.

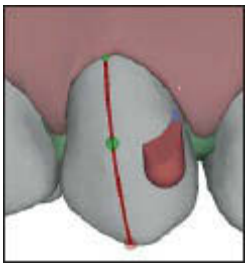


Fig 5-21h A dropletshaped attachment placed along the tooth's vertical axis.

- Make sure the same amount of force is applied from aligner to aligner.
- The attachment should be placed along the tooth's vertical axis.
- Place the attachment in the *active surface area*. This is a zone that engages the attachment to optimize force transfer and reduce unwanted movement (eg, sliding soap effect of extrusion) (Fig 5-21d).

Precautions:

- If an attachment is lost in the course of treatment or wears out abnormally, revert back to the original template (aligner 1) or request a new template from Invisalign if you no longer have this template in order to reproduce the new aligner. This step is imperative because otherwise a part of the correction process will be lost.
- If a mid-course correction or refinement is needed, remove all bonded attachments before taking a new impression. Again, this is necessary to account for all previous corrections.

Droplet-shaped attachments **(Fig 5-21e)**

Droplet-shaped attachments are used for canine rotations. When droplet-shaped attachments are used, the following parameters should be followed (Figs 5-21f and 5-21g):

- Indicated when more than five rotations need to be corrected
- Use when rotating an aligner at least 2 degrees
- Place the attachment on the buccal or labial surface of the tooth and parallel to the vertical axis. The attachment should be placed mesially for mesial rotation and distally for distal rotation (Fig 5-21h).

The aligners are preactivated to reinforce the pressure on the attachment by engaging the active surface area of the attachments. A force on the lingual

surface is simultaneously exerted, which causes the rotation of the tooth (see Fig 5-21f). As with beveled attachments, the active surface area is used to apply a vertical force and avoid unwanted movements of intrusion during rotation (see Fig 5-21d). When multiple adjustments are needed, rotations should be performed prior to extrusion.

Fig 5-21i Ridges in the aligner are formed at the cervical area of the maxillary incisors, providing better torque control.

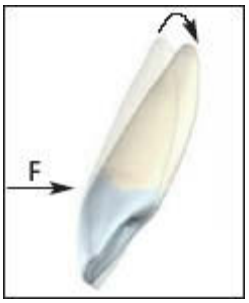


Fig 5-21j Lingual root torque caused by the force of the power ridges

Fig 5-21 k and 5-21l Power ridges on maxillary incisors are used to improve lingual root torque movements

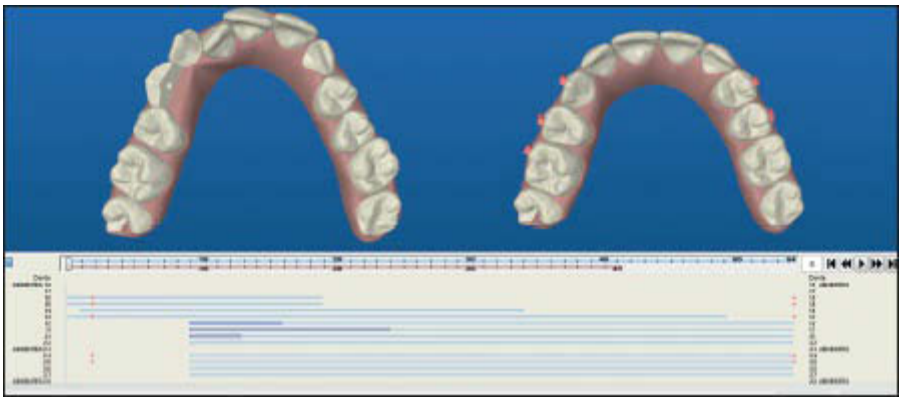


Fig 5-21m Bold dark blue lines indicate power ridges on the ClinCheck staging panel.

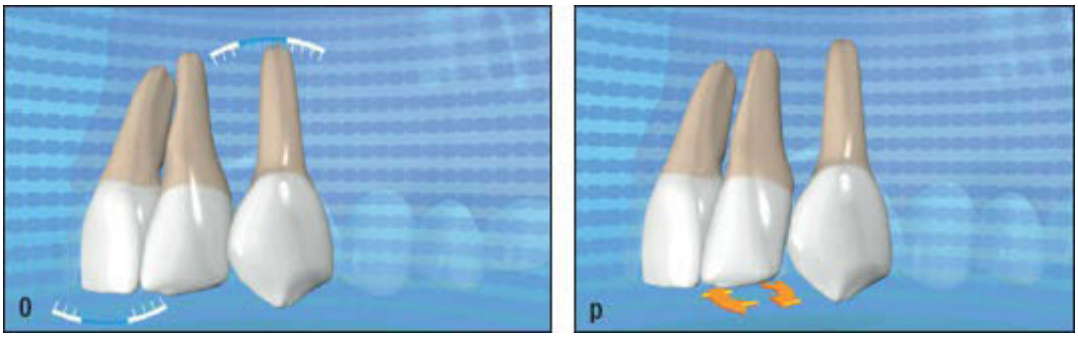
Power Ridges

Introduced for Invisalign Teen treatment, power ridges are now applicable to all types of Invisalign treatment. These ridges are attached to the aligner's lingual surface at the cervical region of the incisors, which results in an increased supporting force of the aligner. The width of the ridge will vary based on tooth size (Fig 5-21i). The power ridges are designed to help deliver lingual root torque movement for better control of the vertical axis of the incisors, especially in the case of incisor extrusion or Class II, division 2 corrections (Fig 5-21j).

When using power ridges, the following parameters should be followed:

- Use when torque of more than 3 degrees is necessary
- Can be placed on both central and lateral incisors
- Only used on maxillary incisors (Figs 5-21k and 5-21l)
- Apply only 1 degree of lingual root torque per treatment stage
- No other attachments should be applied to a tooth where a power ridge is being used
- When several movements are necessary, power ridges should be employed first, followed by extrusion, and then all other movements
- Power ridges appear as dark blue lines in the ClinCheck staging panel (Fig 5-21m)

Fig 5-21n Optimization of displacement velocity based on the virtually recreated root, using six-point registration to determine the displacement of the crown.



Figs 5-21o and 5-21p Movement of the apex and the incisal edge.

Displacement Velocity

The ClinCheck software has been updated to optimize the use of displacement velocity:

- Previously, the axis of the clinical crown was evaluated from three virtual reference points (see Fig 1-22); this has now been changed to six reference points, accounting for both the root and the crown (Fig 5-21n).
- The movement programmed by the software uses the greatest area of movement as its reference; that is, for the same tooth, the movement of the apex is greater than that of the incisal edge (Figs 5-21o and 5-21p).
- The maximum displacement velocity is 0.25 mm per aligner.
- Movements are now slower and more controlled, which increases predictability and actualization.

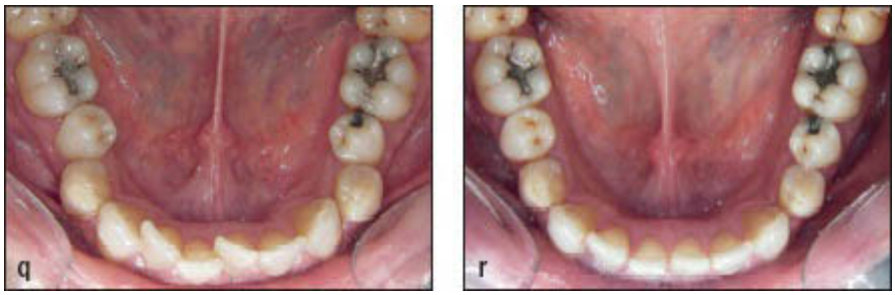
With these new updates, it is recommended to remove previous preferences regarding tooth movement velocities so that the enhanced clinical predictability features will be applied.

Interproximal enamel reduction (IPR)

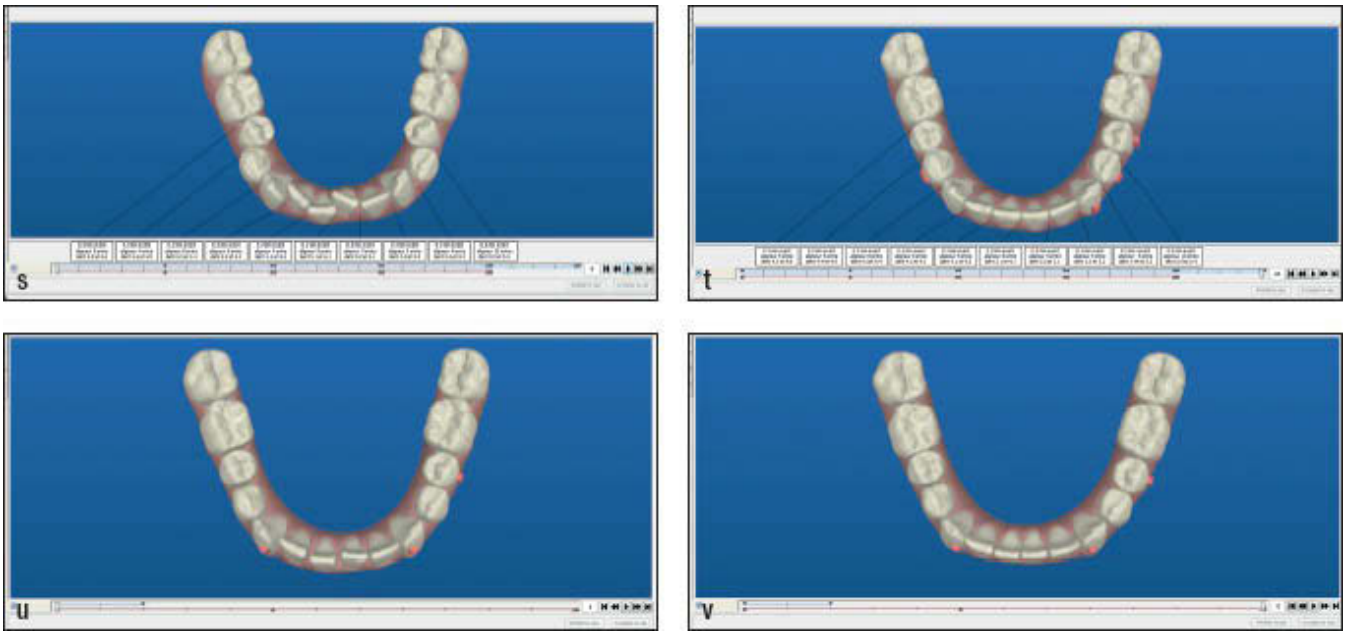
The ClinCheck program, via Treat Software (Performance Systems Development), has been updated in its management of IPR. IPR is indicated later in the treatment in order to:

- Obtain easy clinical access to cutting instruments and avoid stepping (which is caused by grinding that results from tooth crowding). The software will not allow IPR as long as the tooth IPR regions are not in contact (eg, in case of residual collision).
- Avoid beginning treatment with this procedure because it can distress the patient early on.
- Reduce the total amount of IPR and preserve the maximum amount of original enamel (particulary in mandibular incisors) (Figs 5-21q and 5-21r).

The IPR regions are now defined from the final position of the teeth, which results in better posttreatment alignment of the teeth (Figs 5-21s to 5-21v).



Figs 5-21q and 5-21r Example of problems found in a case of excessive IPR before *(q)* and after *(r)* treatment.



Figs 5-21s to 5-21v Before *(s)* and after *(t)* simulated treatment. After effective treatment *(u)* and after refinement *(v)*. The expected result *(t)* is not reached *(u)*. Spacing at the end of treatment *(u)* due to excessive IPR from difficult access of initial tooth crowding requires a refinement *(v)*, which prolongs global treatment duration with 12 additional aligners. This incidence is avoided by the new IPR staging of ClinCheck (enhanced clinical predictability).

Control of Available Space

Interproximal reduction

Indications and contraindications

The benefits of IPR in the Invisalign system have been shown in the previous chapter. According to the author's experience over several years of using this technique and in spite of the reluctance of some orthodontists, IPR proves to be an excellent method to correct crowding in adult patients.

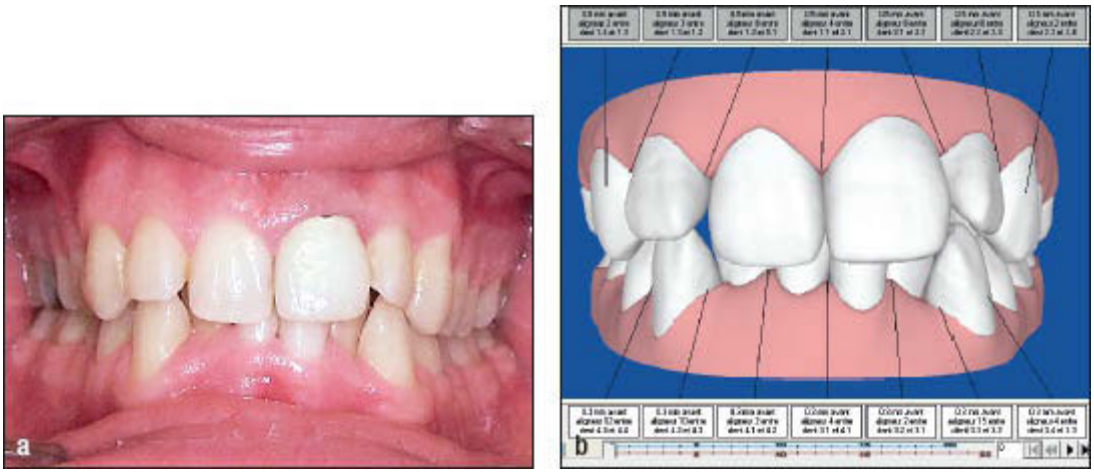


Fig 5-22 *(a)* Clinical situation before treatment. *(b)* ClinCheck simulation of prescribed IPR that is not appropriate to the tooth anatomy.

By sacrificing some enamel, one or more teeth, as well as the corresponding alveolar bone, can be preserved. The treatment duration is thus decreased with reduced treatment stages in certain cases (eg, distalization).

It is highly important to note that the practicability of IPR prescribed by Invisalign must first be verified on ClinCheck. Indeed, the amount of IPR indicated by Align technicians is sometimes incompatible with tooth position or anatomy with regard to the anticipated stage, although this has been reduced with the updates to ClinCheck and the new enhanced clinical predictability features. In case of severe malposition, these reductions can be harmful to normal tooth anatomy or esthetics. In addition, the contact point with adjacent teeth can be unsatisfactory.

For example, in the case shown in Fig 5-22, the technician prescribed IPR of 0.5 mm per contact on the maxilla from canine to canine:

- The reduction is far too much on the mesial and distal aspects of the lateral incisors, which are already much smaller than the canines and central incisors. The result would be unesthetic.
- The maxillary left central incisor is prosthetic and much larger than the adjacent right central incisor. The identical 0.5-mm prescription on the mesial and distal aspects of these two teeth would result in the persistence of the problem of the unesthetic size difference.
- On the other hand, the risk of grinding more on the mesial surface of the right central incisor than that of the prosthetic left central incisor is significant. Since ceramic is harder than enamel, as the instrument passes through the contact point during IPR, it will have a greater effect on the

right central incisor than on the prosthetic left central incisor, thus accentuating the size difference of these two teeth.

In the example shown in Fig 5-23, the technician prescribed 0.5 mm of IPR between the mandibular left central and lateral incisors and between the mandibular central incisors in stage 1. This approach is technically impracticable in the mouth without damaging tooth anatomy and will result in the mandibular left lateral incisor being overly ground.

At stage 7, after IPR has been performed as much as possible according to the prescription, modified tooth anatomy, significant loss of enamel, and flattening of contact points (in particular between the mandibular left canine and first premolar and surrounding the mandibular left lateral incisor, on which an attachment could still be bonded) are noted (see Fig 5-23f). Nevertheless, all the prescribed IPR could not be realized. Furthermore, in this adult patient, extraction of the mandibular central incisor was indicated (see Fig 5-23g); nevertheless, the simulated result without extraction seems better (see Fig 5-23h) and at the end of treatment, the incisors are properly aligned (Figs 5-23i and 5-23j).

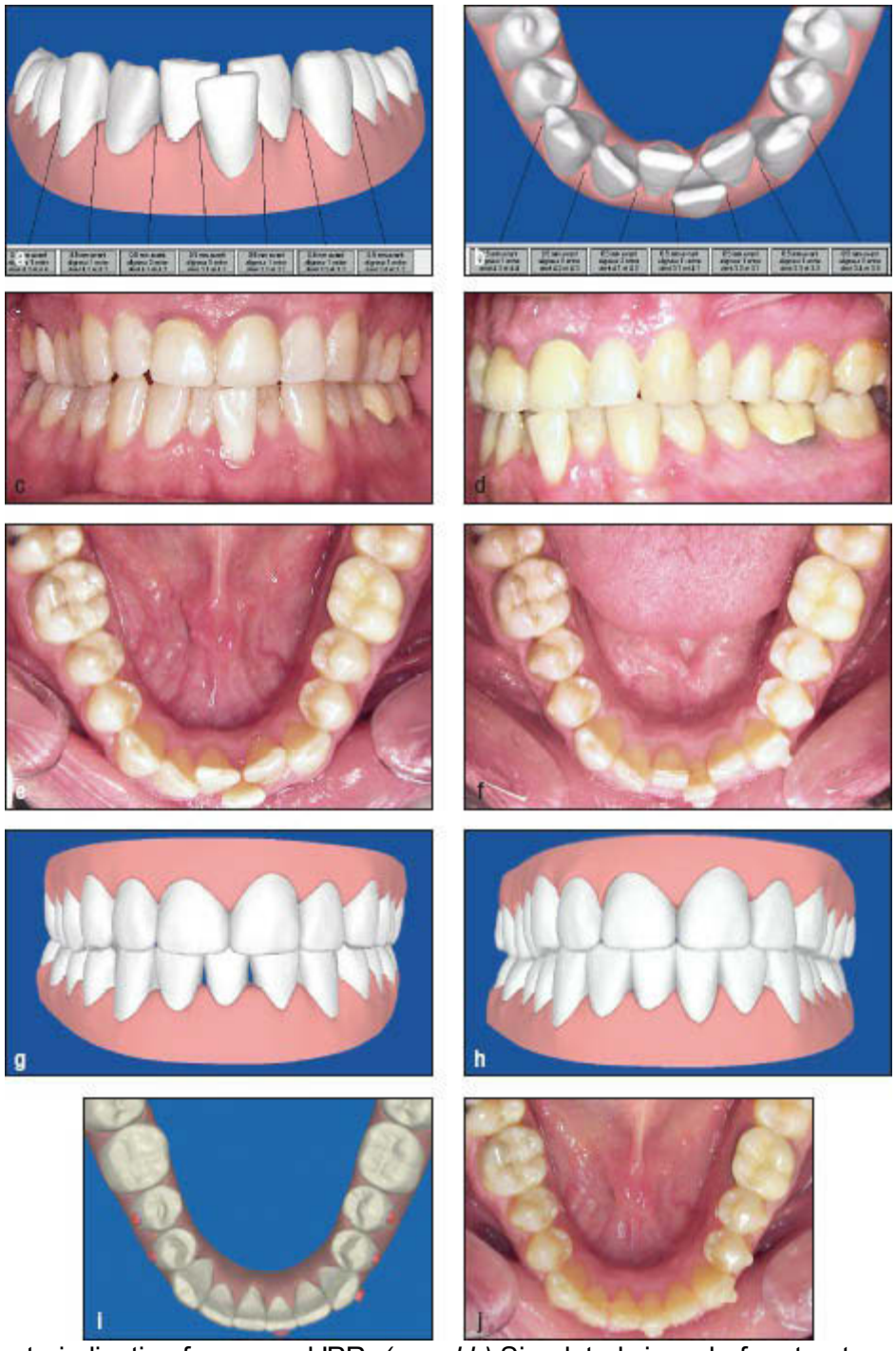


Fig 5-23 Contraindication for enamel IPR. *(a and b)* Simulated views before treatment showing the prescribed IPR. *(c to e)* Intraoral views before treatment. *(f)* Occlusal view at stage 7. *(g)* Simulated treatment result with extraction of a mandibular central incisor. *(h)* Simulated treatment result without extraction. *(i and j)* End of treatment with proper alignment of incisors after IPR: stage 15 of 16.

Table 5-2	Personal IPR chart						
	I_1	I_2	C	B_1	B_2	M_1	M_2
Maxillary	0.1 to 0.5 mm	0.1 to 0.4 mm	0.1 to 0.5 mm	0.1 to 0.5 mm	0.1 to 0.5 mm	0.1 to 0.6 mm	0.1 to 0.5 mm
Mandibular	0.1 to 0.3 mm	0.1 to 0.3 mm	0.1 to 0.5 mm	0.1 to 0.5 mm	0.1 to 0.5 mm	0.1 to 1.0 mm	0.1 to 0.6 mm

Table 5-3	Instruments recommended for IPR		
0.1 to 0.3 mm	0.1 to 0.3 mm	0.1 to 0.3 mm	Any distance
Simple: Minimal crowding, slight rotations, anterior teeth	Difficult: Severe crowding, severe rotation, anterior teeth	Mandibular anterior teeth, posterior teeth, distalization	All teeth
Disc	Mini-saw	Drill	Gauges

Materials and methods for IPR (Tables 5-2 and 5-3)

When 0.1 to 0.3 mm of enamel is to be removed, it is best to use low-speed diamond-coated disks (Fig 5-24) with:

- One or two abrasive surfaces
- Small diameter for mandibular teeth
- Large diameter for maxillary teeth

When 0.3 to 0.6 mm of enamel is to be removed, high-speed needle-tipped burs are used (Fig 5-25).

If teeth are difficult to access such as in cases of severe crowding, mini-saws or strips in holders mounted on contra-angle handpieces are used to recontour tooth anatomy without risk of overreduction (Fig 5-26). Finishing is performed with abrasive paper and thickness gauges to control the amount of tooth surface removed (Fig 5-27).

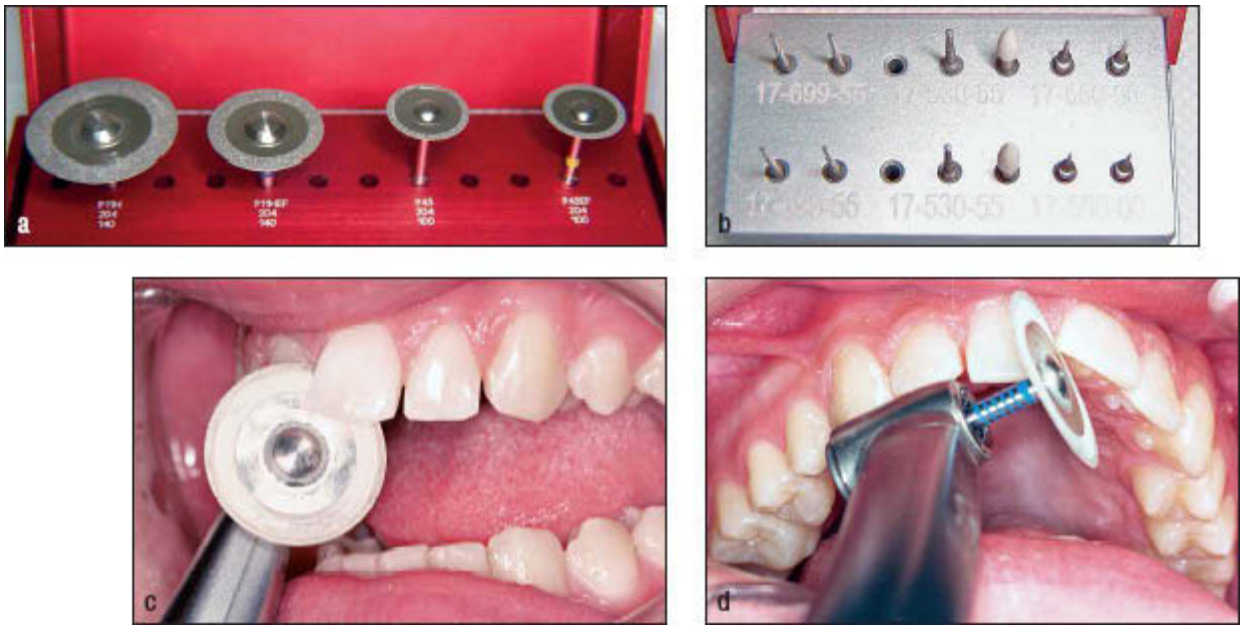


Fig 5-24 *(a and b)* Low-speed diamond-coated disks and finishing burs for 0.1- to 0.3-mm enamel reduction. *(c and d)* Reduction in the mouth.

Fig 5-25 High-speed needle-tipped diamond burs used for enamel reduction of 0.3 to 0.6 mm.

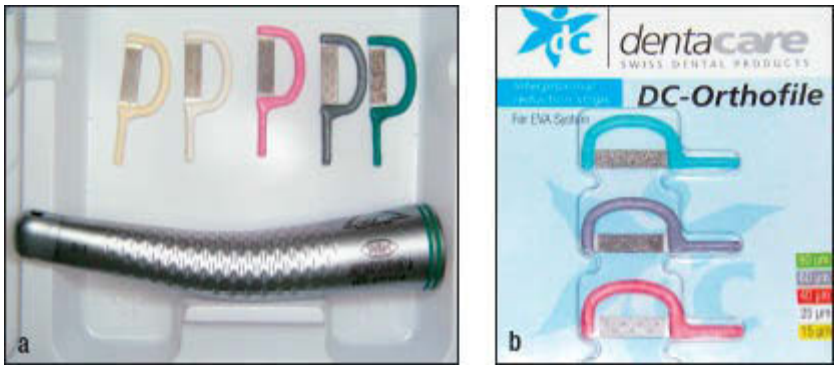


Fig 5-26 Contra-angle handpiece with attachable strips in holders *(a)* and mini-saws *(b)*.

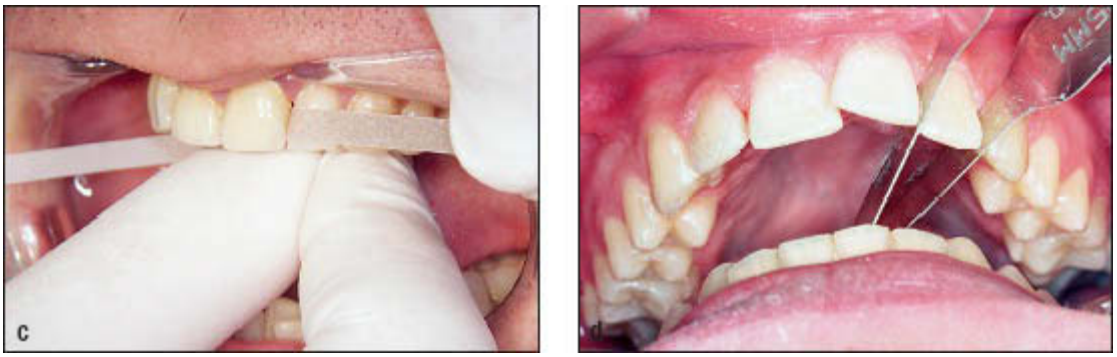


Fig 5-27 Finishing with abrasive paper *(a)* and thickness gauges *(b)*.

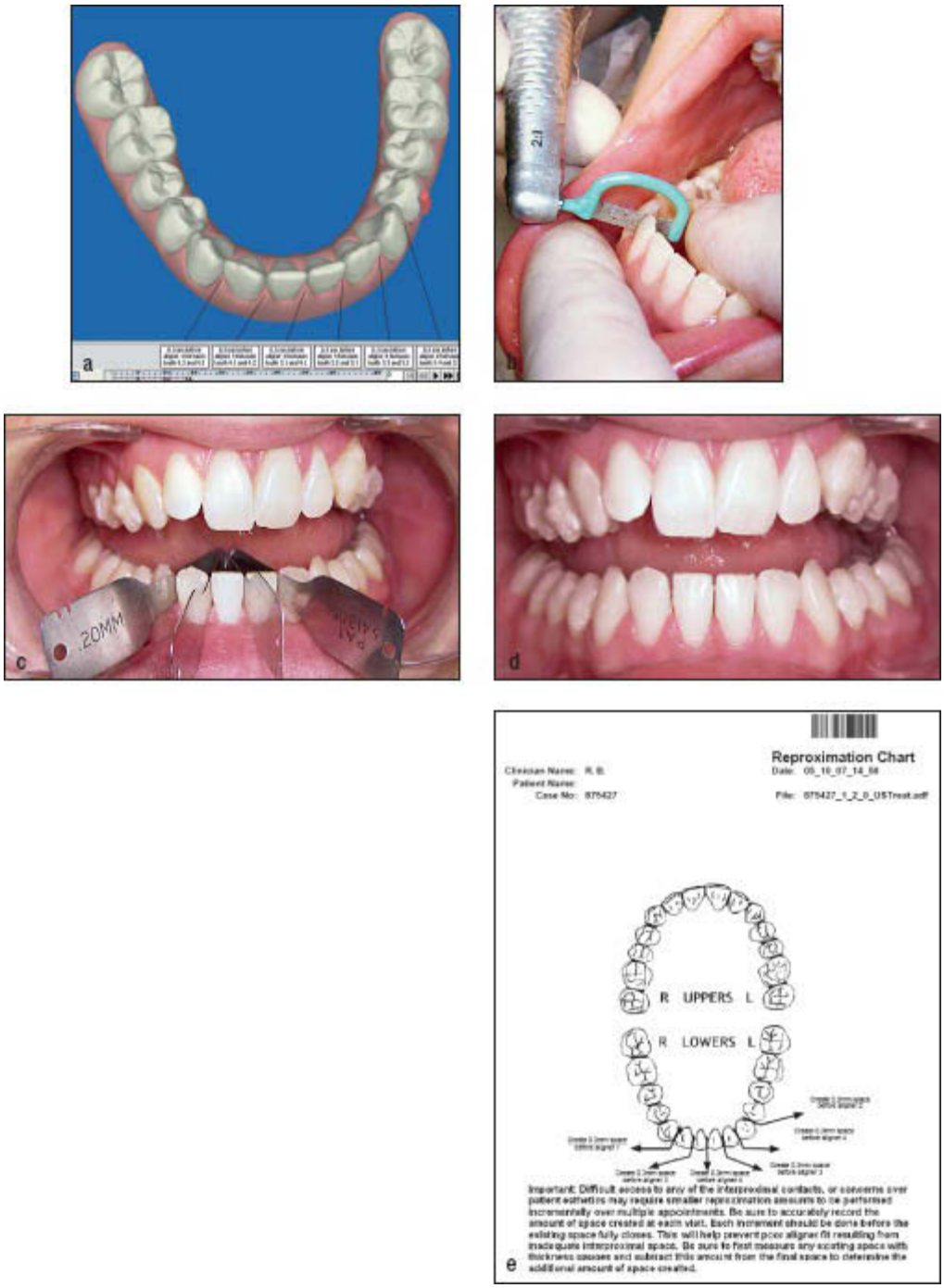


Fig 5-28 *(a)* ClinCheck setup detailing IPR. *(b to d)* IPR performed in the mandibular anterior teeth of a patient. *(e)* IPR chart.

Fig 5-29 The position and amount of IPR are noted on the bags containing new aligners.

An example of IPR is shown in Fig 5-28. IPR is visually detailed on ClinCheck setups (see Fig 5-28a). Note that IPR, like attachments, is also indicated on an online form accessible on VIP. A printed copy of this form is provided in the box of aligners (see Fig 5-28e), and the amount and position of IPR are also noted on the bags containing the aligners (Fig 5-29).

Fig 5-30 Pontics replacing the maxillary central incisors after traumatic tooth loss. *(a and b)* Without aligners. *(c and d)* With aligners.

Control of Anchorage Loss

Use of pontics in extraction spaces

An extraction space may be:

- Maintained (for prosthetic purposes)
- Reduced (to alleviate crowding)
- Increased (for implant placement)

During these procedures, one or more missing teeth will be replaced, if requested, by composite resin pontics included in the aligner. Pontics are shown replacing the maxillary central incisors in an adolescent patient after traumatic tooth loss in Fig 5-30. Figure 5-31 shows a single pontic replacing an anterior tooth in an adult patient after extraction. In Fig 5-32, pontics were used to replace posterior teeth on the left side of both arches in an adult affected by periodontitis in preparation for implant-supported prosthetic rehabilitation. Note that in this case, the pontics do not match the color of the adjacent teeth, creating an unnatural effect. It is important to select a color of composite resin that will blend in with the surrounding teeth.

Maxillomandibular elastic traction

In Invisalign treatment—as in fixed orthodontics—maxillomandibular elastic traction is used for anchorage control or to reduce a sagittal discrepancy of Class II or, in some cases, Class III occlusions. To create anchorage for the elastic in the aligner, a sharp forceps is used either to make a hole in the aligner for the elastic to slide through or to clip the aligner's border between the maxillary lateral incisor and canine or canine and premolar for Class II elastic traction as proposed by Paquette[1,2] (Fig 5-33).

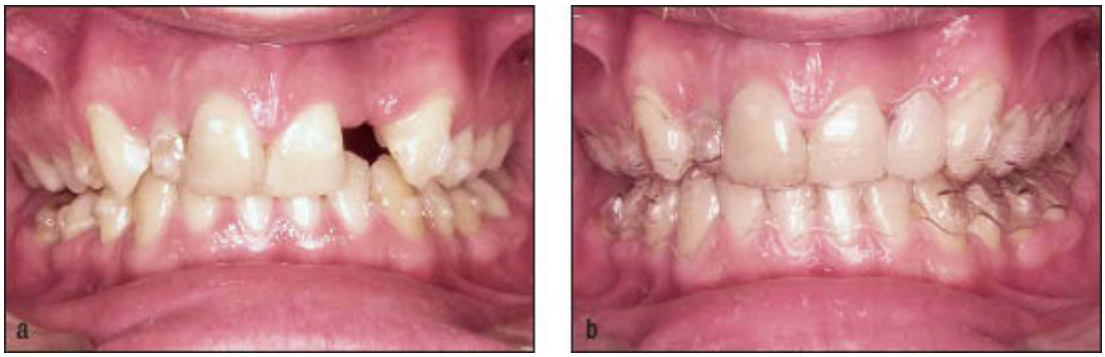


Fig 5-31 Pontic replacing the maxillary left lateral incisor. *(a)* Without aligners. *(b)* With aligners.

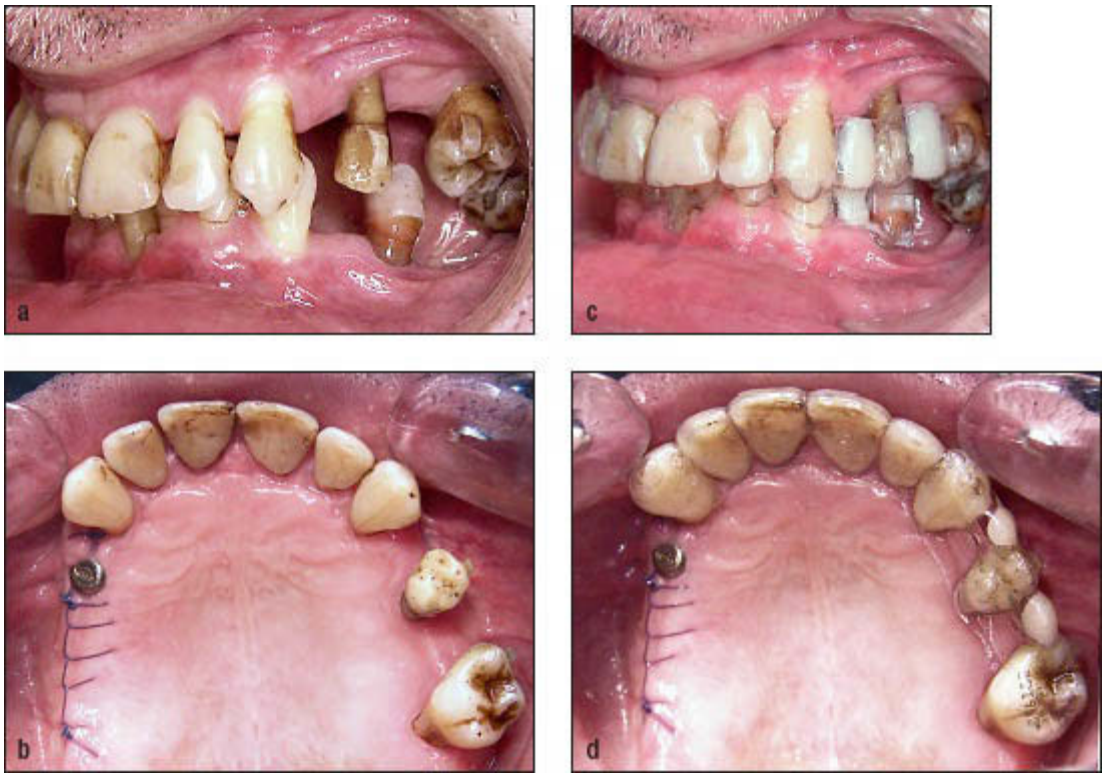


Fig 5-32 Patient with periodontitis treated with Invisalign with pontics in preparation for implant-supported restorations. Note the unnatural effect created by the poor match in shade between the pontics and the teeth. *(a and b)* Without aligners. *(c and d)* With aligners. (Surgery by Y. Dislaire. Periodontics by J. Charon.)

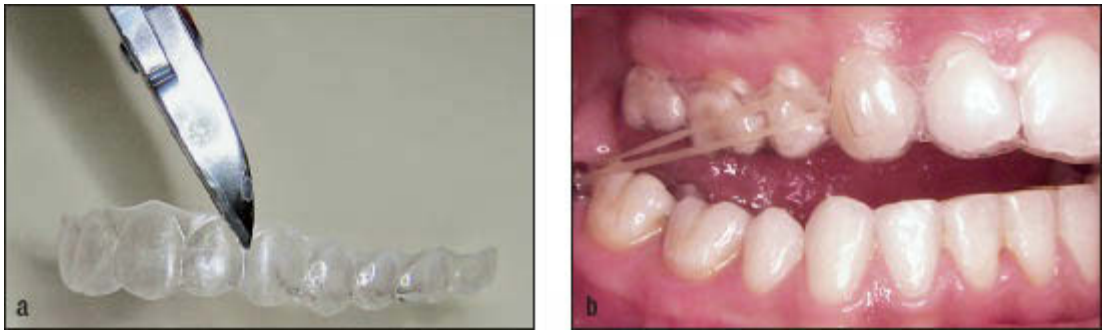


Fig 5-33 Modification of an aligner for elastic fixation *(a)*; aligner and maxillomandibular elastic traction in place *(b)*.

Fig 5-34 Elastic fixation with *(a and b)* and without *(c and d)* aligners in the mandible.

Several modes of elastic fixation are possible in the mandible:

- If a mandibular aligner is in use, a hole is cut in the aligner on the buccal aspect of a molar, where a metal or ceramic attachment is bonded to hook the elastic (Figs 5-34a and 5-34b).
- When Invisalign treatment is complete in the mandible, a lingual bonded fiber-reinforced splint (everStick [Stick Tech] or Ribbond-THM [Ribbond]) is placed under rubber dam from canine to canine. For elastic fixation, a lingual archwire that includes ring clasps with buccal brackets on the first molars is attached to the splint. The elastic is then attached to the buccal brackets (Figs 5-34c and 5-34d).
- The author uses mini-implants for mandibular elastic fixation because they ensure the best anchorage control. Mini-implants are placed under local anesthesia in the retromolar triangle distal of the mandibular first or second molars, then the elastic is fixed directly to the implant. An example of placement of a mini-implant for maxillomandibular elastic attachment is shown in Fig 5-35.

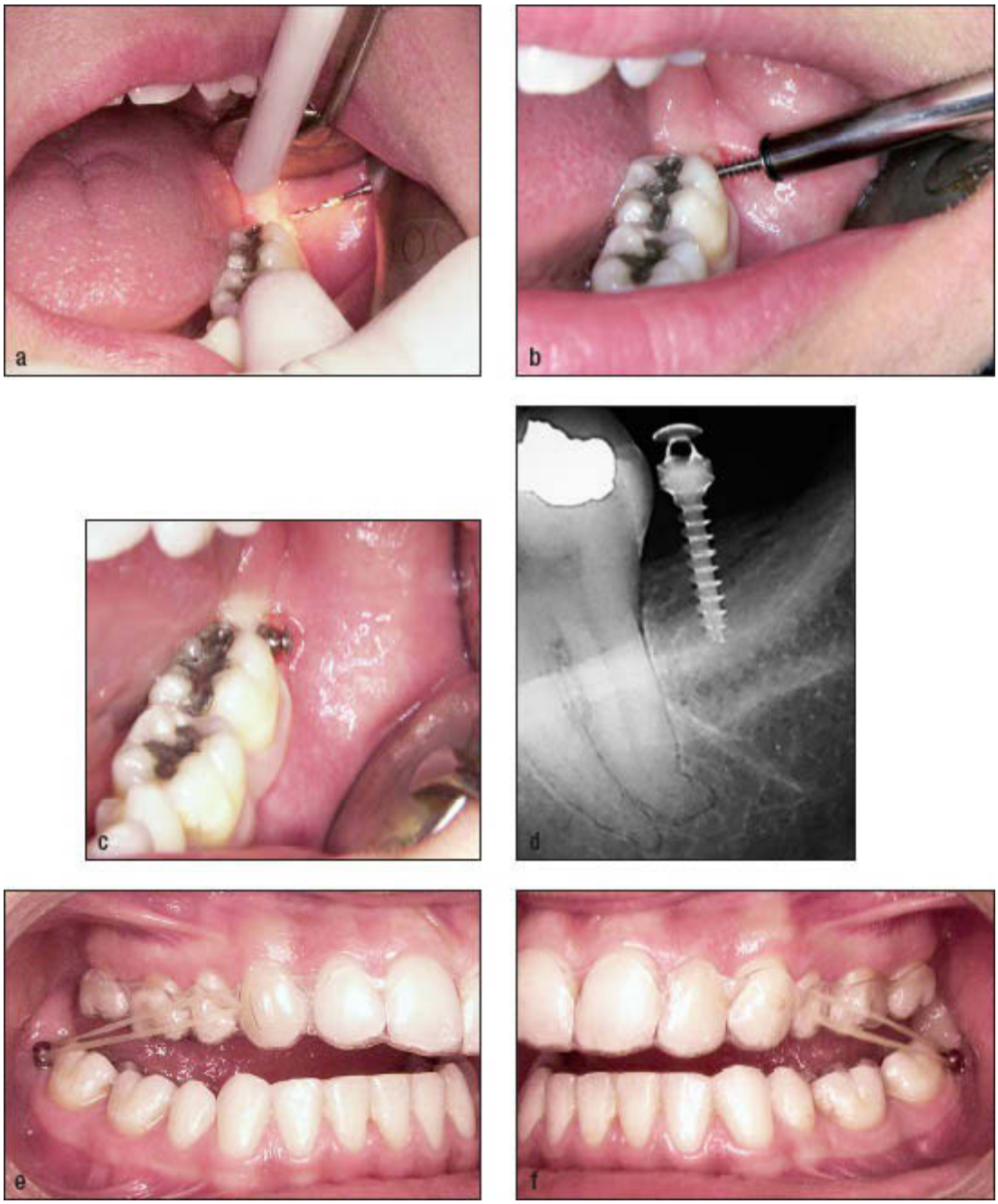


Fig 5-35 Placement of a mini-implant for maxillomandibular elastic traction. (Surgery by P. Lambert.) *(a)* Bone drilling with a rotary instrument. *(b)* Placement with a manual screwdriver. *(c)* Mini-implant in place. *(d)* Control radiograph of mini-implant. *(e and f)* Maxi l lomandibu lar elastic traction anchored to themini-implant. *(Continued)*

If maxillomandibular elastic traction is to be used, it is best to plan the placement of attachments using ClinCheck. For maximum invisibility of class II elastics in an adult patient, make a second hole more posterior on the maxillary aligner between the canine and premolar for day-time traction by using latex-free elastics (perfectly transparent thus rendering the highest discretion) and reposition classic yellow latex elastics (more powerful)

between lateral incisor and canine for better, night-time traction.

Fig 5-35 *(g to l)* Teen treatment: The simple method of placing elastic through the holes initially made with pliers (designed by Dr Schwarz) in the maxillary aligner between the lateral incisor and canine. Note: miniscrews (Dentaurum) are used for as an easy and directional elastic attachment (independent from the axis g of implant placement).

Closing extraction spaces

For certain patients requiring extraction (eg, those with a retrusive profile or ageneses), the extraction space will not be managed by maintaining anchorage but, on the contrary, by controlled anchorage loss to close the space.

This anchorage loss will be simulated during setup of ClinCheck, and superimposition will be used to visually quantify the anchorage loss to be performed. Mesialization of posterior teeth can then be better visualized and understood. In the author's clinical experience with the Invisalign system, mesialization is markedly easier to perform with maxillary molars than with mandibular molars (as is true with the use of fixed appliances). Root axis control during tooth movement is better in the maxilla, which limits tooth tipping. Rectangular attachments should be used to actively participate in

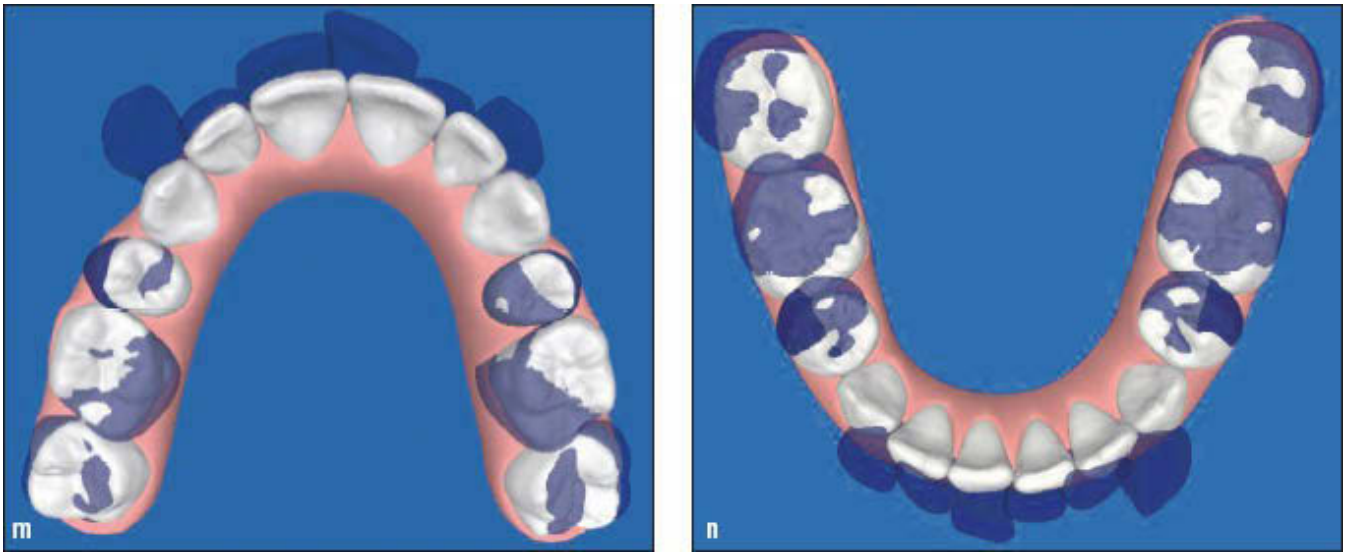
the control of axes. In case of treatment difficulty, the velocity of movement should be reduced by, for example, wearing each aligner for 3 weeks instead of the usual 2 weeks.

If tipping becomes so accentuated that the tooth moves out of the aligner —the phenomenon the author calls the “sliding soap effect”—the clinician should not hesitate to prescribe finishing (ie, refinement) during the last three stages of treatment or a correction in the course of treatment (ie, midcourse correction) to avoid aggravating this condition.

An example of treatment with controlled anchorage loss following extraction of all four first premolars to correct severe anterior crowding is shown in Fig 5-36. The treatment required 39 maxillary aligners (19.5 months) and 24 mandibular aligners (12 months). Rectangular attachments were placed on the teeth adjacent to the extraction sites.

Figs 5-36a to 5-36j Invisalign treatment with extraction of all four first premolars. *(a to e)* Before treatment. *(f to j)* After treatment.

Figs 5-36k and 5-36l *(k)* Before treatment. *(l)* After treatment. The loss of anchorage in the mandibular premolars and molars is clearly demonstrated, whereas less anchorage loss is shown in the maxilla.



Figs 5-36m and 5-36n The ClinCheck treatment simulation is reviewed using the superimpose tool (*blue*, before treatment; *white*, after treatment).

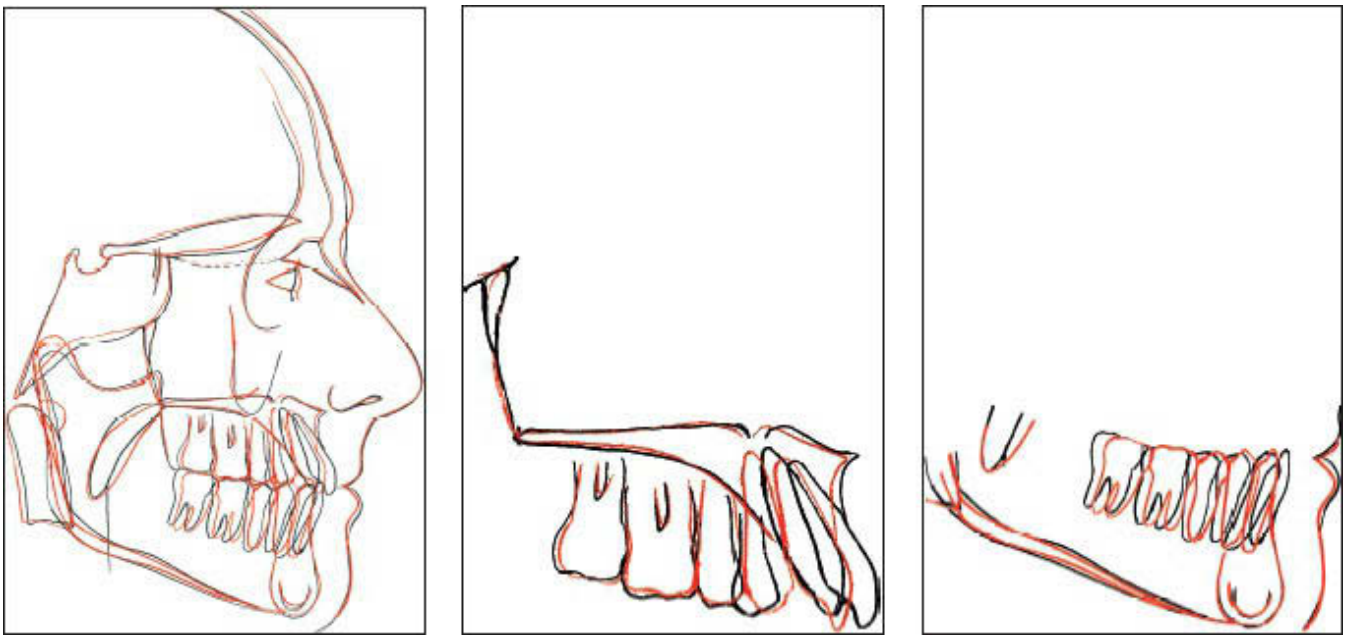


Fig 5-36o Superimpositions of cephalometric tracings before and after treatment (*black*, before treatment; *red*, after treatment).

Fig 5-36p Superimposition of the patient's profiles before *(background)* and after *(foreground)* treatment.

Fig 5-36q Facial view after treatment.

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2. Paquette D. ClinCheck as a tool for therapeutic diagnosis. Orthodontic CyberJournal. http://www.ocj.com/oct05/Invisalign_2.htm. Published October 2005. Accessed 1 March 2010.

Indications and Contraindications

6

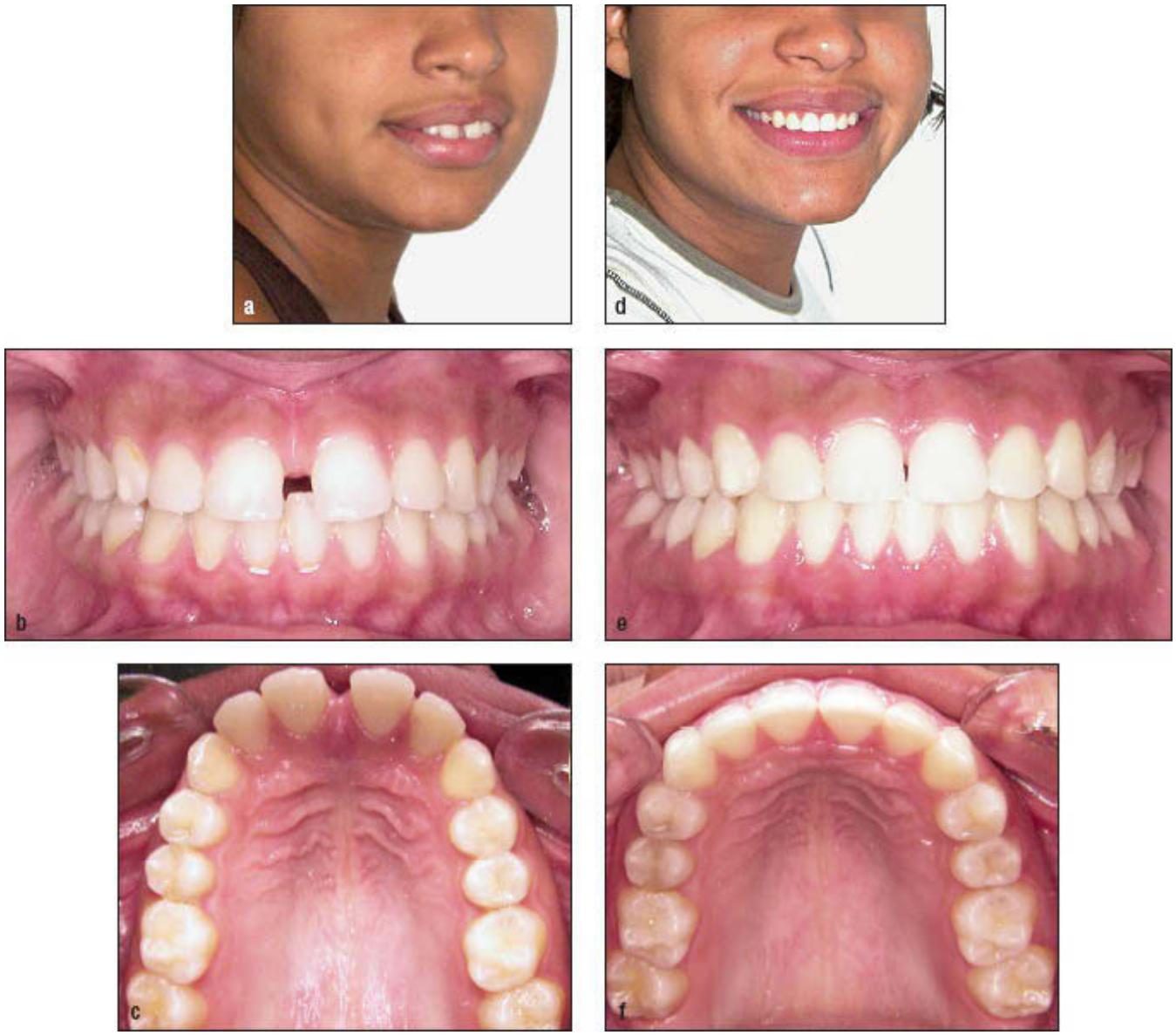


Fig 6-1 Closure of anterior spacing. *(a to c)* Before treatment. *(d to f)* After treatment, which involved 16 maxillary and 12 mandibular aligners (8 and 6 months of treatment, respectively).

Indications

Following are ideal case types to be treated according to the practitioner's level of familiarity with the Invisalign system.

Level I: 1 to 10 cases treated per year

- Angle Class I occlusion
- Anterior spacing (Fig 6-1)

• Mild anterior crowding

Fig 6-2 Correction of crowding, molar crossbite, and Class II malocclusion. *(a to d)* Before treatment. *(e to h)* After treatment, which involved 34 maxillary and 24 mandibular aligners (17 and 12 months of treatment, respectively).

Level II: 10 to 30 cases treated per year

- Mild angle Class II malocclusion: Class II, division 1 and Class II, division 2 (treated by distalization and interproximal reduction [IPR])
- Anterior crossbite and single posterior crossbite
- Mild angle Class III malocclusion
- Prosthetic and implant preparations (eg, space reopening)
- Slight periodontal attachment loss from periodontitis
- Severe crowding (treated by extraction, IPR)

An example of a case appropriate for this level is shown in Fig 6-2.

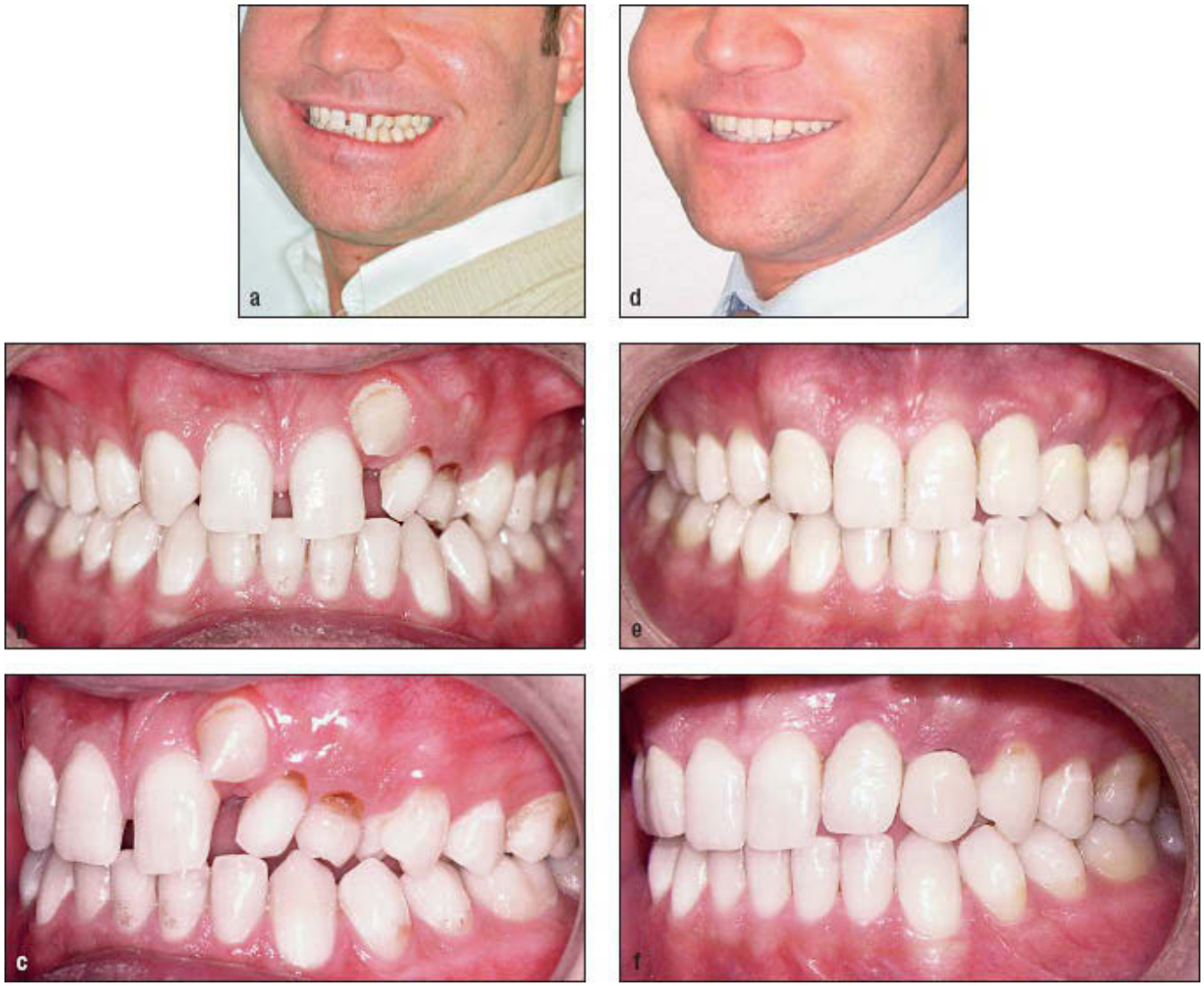


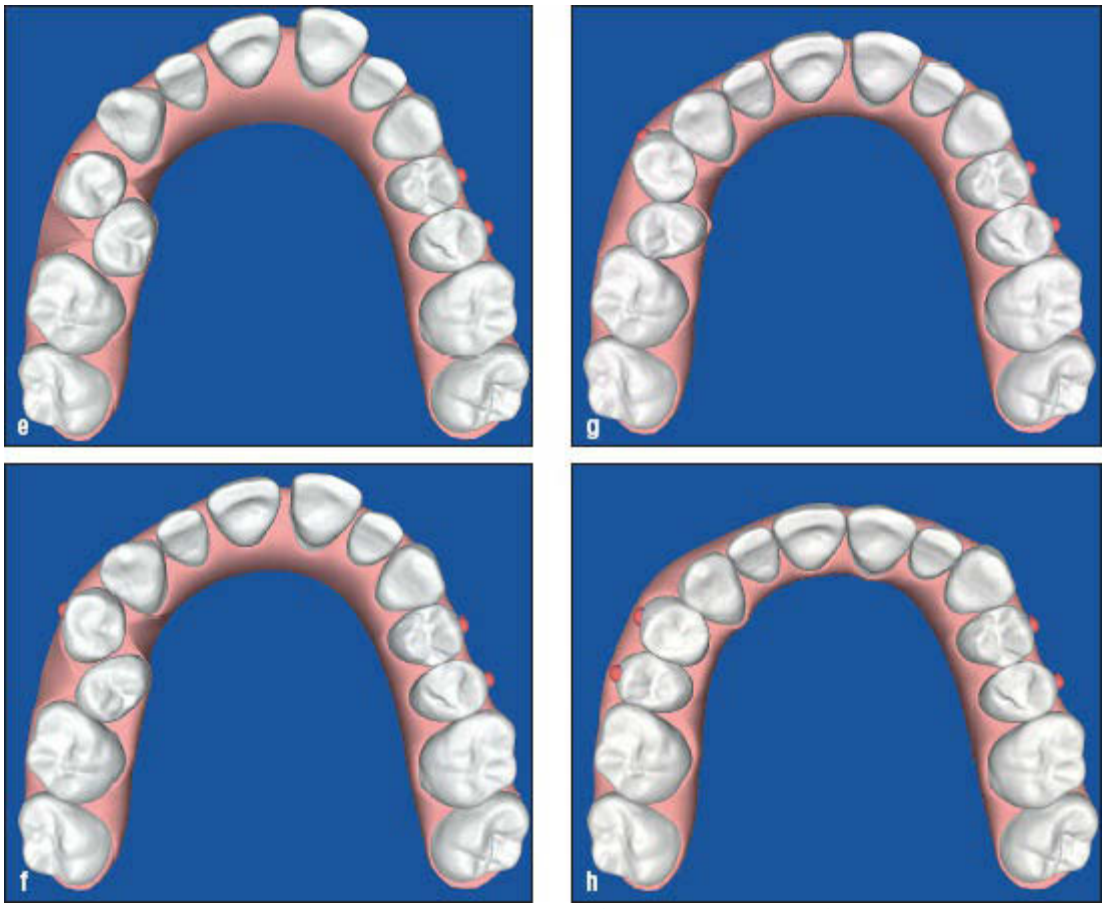
Fig 6-3 *(a to c)* Patient presenting with an impacted maxillary left canine, agenesis of both maxillary lateral incisors, spacing between the central incisors, and retention of primaryteeth. *(d to f)* After treatment, which involved 38 maxillary aligners (19 months of treatment). (Prosthetic rehabilitation by E. Pottie.)

Level III: 30 to 80 cases treated per year

- Treatment with extraction
- Impacted canines
- Mixed dentition (retained primary teeth, ageneses)
- Treatment in adolescents
- Unilateral complete posterior crossbites
- Angle class II malocclusion with intermaxillary elastic traction
- Angle class III malocclusion with intermaxillary elastic traction
- Orthosurgical preparation

An example of a case appropriate for this level is shown in Fig 6-3.

Figs 6-4a to 6-4d *(a and b)* Before treatment. The maxillary right first and second premolars are malpositioned. *(c and d)* After treatment. The premolars are repositioned.



Figs 6-4e to 6-4h ClinCheck simulation of stages 1 *(e)*, 9 *(f)*, 18 *(g)*, and 28 *(h)*.

Level IV: 80 or more cases treated per year

- Extreme movements such as rotation and severe tooth wear
- Severe periodontal attachment loss from periodontitis
- Extremely complicated cases

An example of a case appropriate for this level is shown in Fig 6-4.

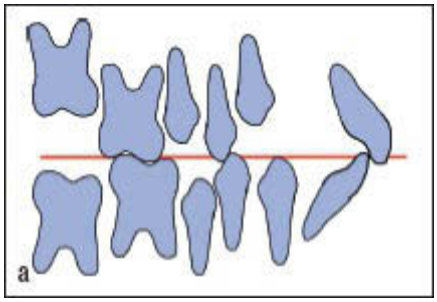
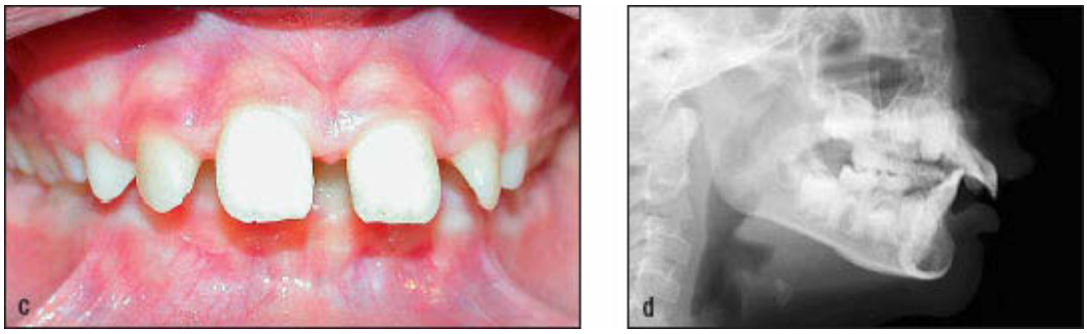


Fig 6-5a With a complete eruption of first premolars, the occlusal plane can be established. Before this stage, the treatment with Teen Invisalign is contraindicated.

Fig 6-5b With a minimal clinical profile of tooth eruption for a treatment with Teen Invisalign, spaces reserved for future eruption of permanent teeth on the arch will be managed with the ClinCheck Teen *eruption control* features.



Figs 6-5c and 6-5d Hypodivergent facial profile, deep overbite, and mandibular retrusion all require initial orthopedic intervention.

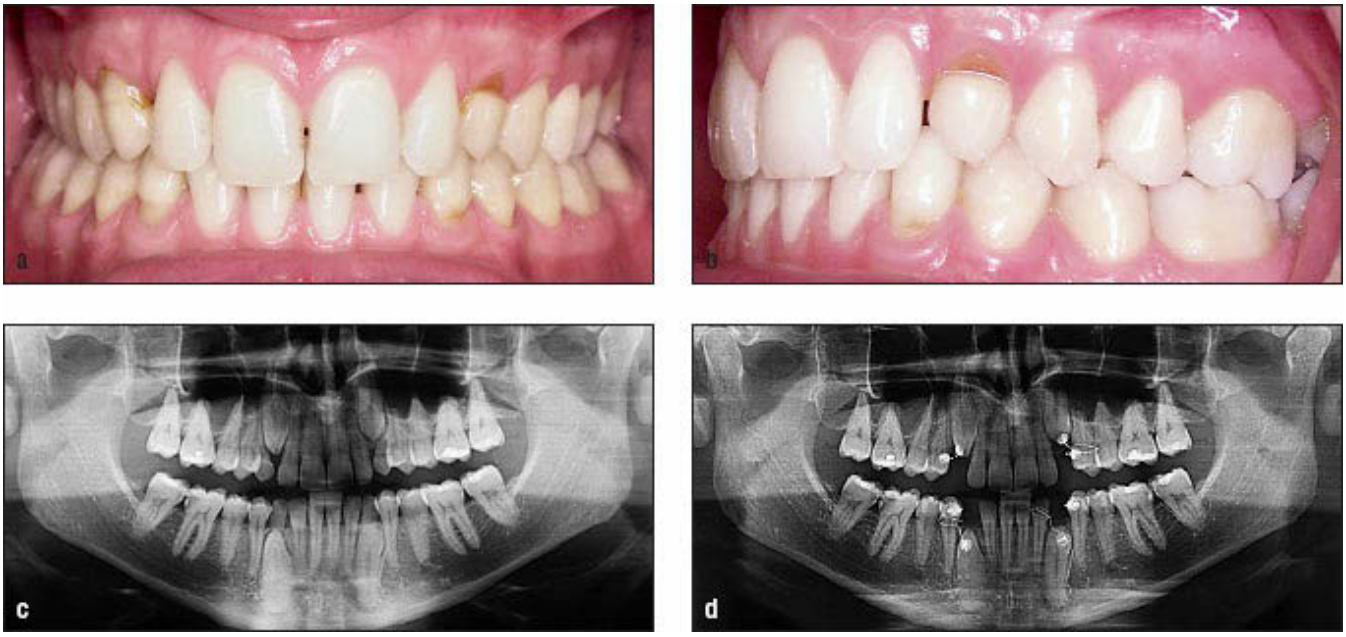
Contraindications

Patient factors

- Age: Patients with primary or mixed dentition are too young for Invisalign treatment. However, a new Invisalign system called “Teen,” which is specifically designed for adolescents, is now available. The Invisalign Teen system is designed for children age 10 or older if first premolars are completely erupted, while canines and second premolars can still be in the course of eruption (Figs 6-5a and 6-5b).
- General health contradicting the treatment.
- Psychologic profile, eg, depression due to recent loss of job or divorce.
- Patients with hypodivergent facial profile, ie, deep overbite (Figs 6-5c and

6-5d).

- Growth abnormalities: hypodivergent facial mophology and mandibular retrusion, which requires an initial orthopedic intervention (eg, with a monoblock activator [Lautrou]).



Figs 6-6a to 6-6d *(a to c)* Patient presenting with four impacted canines. *(d)* After extraction of primary teeth. Surgical extrusion of permanent canines is carried out with bonded traction attachments.

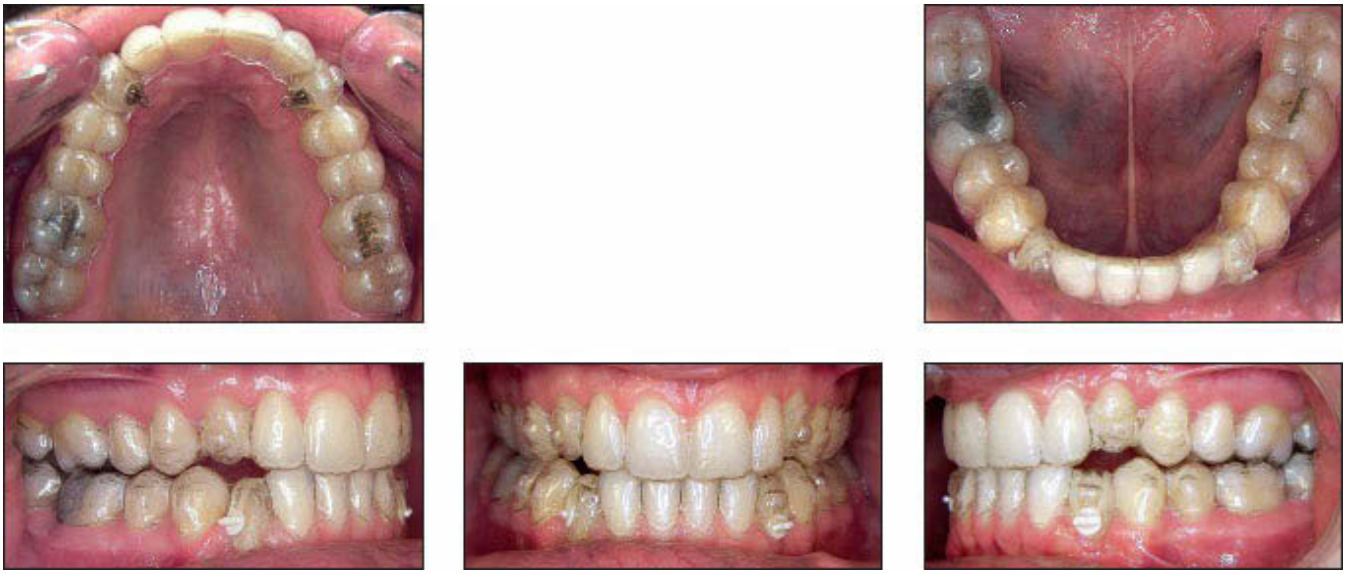


Fig 6-6e Traction of 4 impacted canines in an adult patient with Invisalign: Elastics are attached to the teeth on classic orthodontic attachments and on the aligner through holes made with pliers (Dr Schwarze). At stage 25 of 40 disimpaction and then extrusion of permanent canines are observed (treatment in progress). (Surgery by Y. Dislaire.)

Tooth factors

- Teeth with anatomy unfavorable to force transmission from aligners, eg, short, round, or peg-shaped teeth
- Teeth requiring dental treatment
- Impacted teeth (Figs 6-6a to 6-6e)

Occlusion factors

- Severe extrusion or intrusion
- Deep overbite
- Anterior or posterior open bite
- Need for combined treatments (eg, pretreatment, mini-implant placement, surgery)

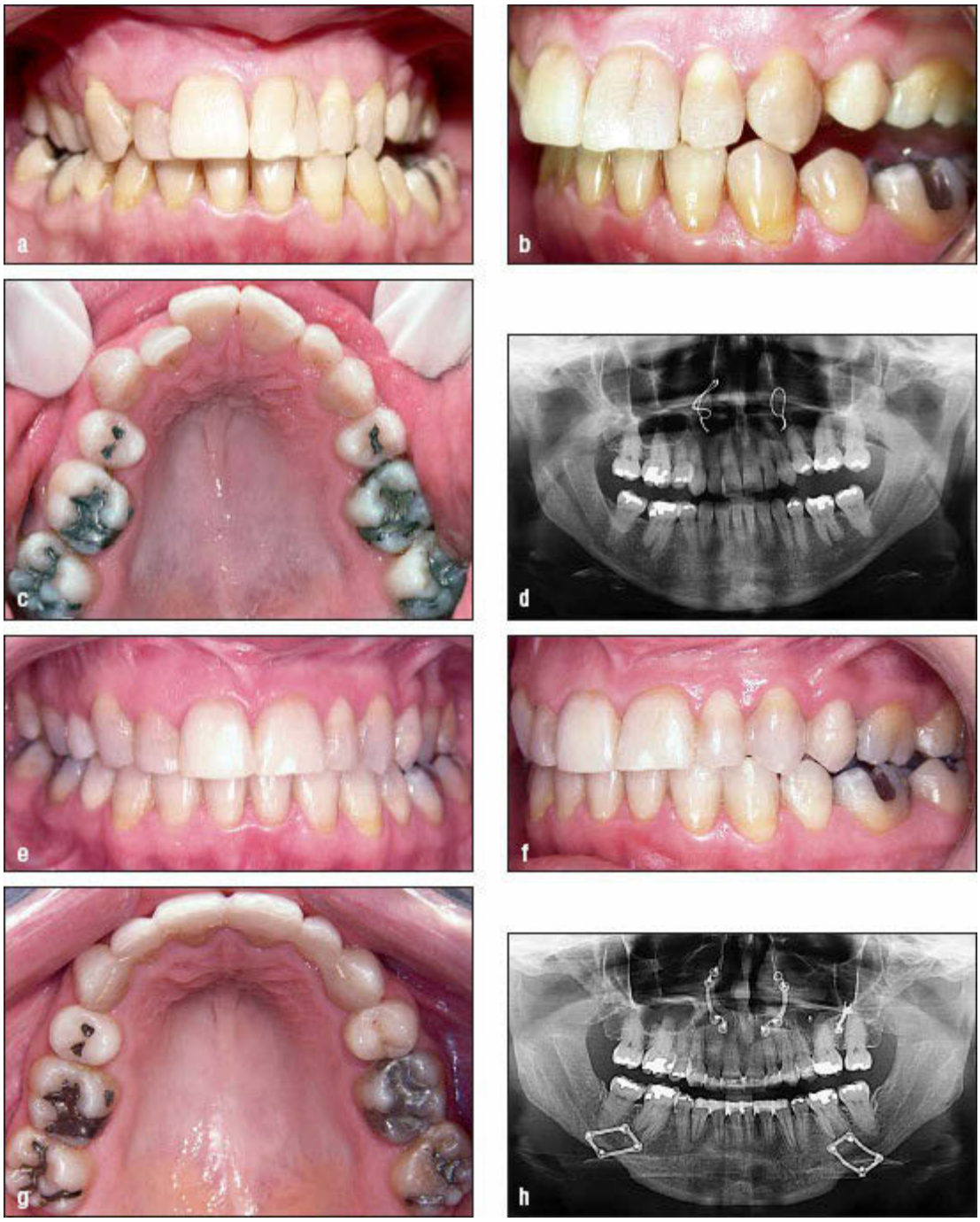


Fig 6-7 *(a to d)* Occlusal situation before orthosurgical retreatment. *(e to h)* Occlusal situation after orthosurgical retreatment. (Surgery by Y. Dislaire.)

For example, the patient shown in Fig 6-7 presented with painful dysfunction of the left temporomandibular joint as a consequence of a left posterior open bite resulting from orthosurgical treatment with extraction of four premolars and total maxillary osteotomy (Le Fort I) with stainless steel wire suspension. Invisalign treatment alone would not be sufficient to treat this case. The patient required orthosurgical retreatment. Arch leveling was

performed using the Invisalign system with 16 maxillary and 16 mandibular aligners. Then maxillomandibular intervention was carried out using a total osteotomy (Le Fort I), left maxillary bone graft, and total mandibular sagittal Dal Pont–Obwegeser osteotomy.

Conclusion

The Invisalign system is rather new. It was introduced in the late 1990s and is still in a very dynamic state of development. Clinicians have participated in these first steps of development by using the system to treat their patients; however, many questions regarding its treatment efficacy have been raised and in some cases still remain unanswered.

More perspective on the results of Invisalign treatment is still needed, as is more basic research on the biology, physics, and biomechanics of tooth movements by aligners. A combination of tooth movement simulations and growth predictions should also be developed. The clinical results presented in this book should be viewed as only one contribution to the ongoing development of the Invisalign technique, which should be perceived as an orthodontic treatment method under development, not as an already well-established and systematized technique. Results can sometimes be exceptional, surprising, or disappointing. Most failures are, in the author's opinion, due to the current lack of fundamental knowledge about the biomechanics of aligners and the related data processing applications.

Progress in the control of tooth movement by aligners during the last 10 years shows that the research conducted by Align Technology as well as university researchers and clinical experience throughout the world are resulting in a gradual maturation of the system. For example, a classification of treatment choices depending on the type of malocclusion can now be established.

Invisalign treatment opens for orthodontists a new era in which they will no longer be considered "wire technicians," but rather cognitive clinicians whose orthodontic knowledge must be applied before active treatment is begun. However, undertaking Invisalign treatment is not easy since it requires humility regarding our current knowledge base and open-mindedness toward the sometimes highly technical and dogmatic nature of the system. Nevertheless, it provides exceptional opportunities. For example, in a society in which communication and information have become highly prized,

animated on-screen demonstrations of envisaged tooth movements offer a unique way for the patient to come to a rapid and complete understanding of proposed orthodontic treatment. Future developments based on biologic and biomechanical knowledge, as well as three-dimensional imaging, are likewise highly promising.

The author hopes that this book will facilitate the reader's access to this up-and-coming technique. With the well-being of patients in mind, perhaps some readers will take it one step further and participate in the improvement of this technique so that it may reach its full potential as one effective treatment option among the many available to orthodontists.

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