Is Invisalign® new?

Yes and no! As early as in 1945, Kesling wrote: ‘Major tooth movements could be accomplished with a series of Positioners by changing the teeth on the setup slightly as treatment progresses.’ From 1971 onwards, several publications on clear appliances appeared. These appliances were mainly used as retainers because, as active appliances, they lacked precision and required too much work to move teeth into the desired positions (Ponitz 1971; McNamara et al. 1985; Sheridan et al. 1993; Rinchuse and Rinchuse 1997).

With the computer-aided design/computer-aided manufacture (CAD/CAM)-based Invisalign System introduced in 1997, the idea of moving teeth with clear plastic appliances took a new turn.

How does Invisalign work?

The present text reflects the state of the art in technology and therapeutic possibilities at the time of writing (2006)

Align Technology is continuously developing novel methods to improve the process. Each treatment is based on a complete set of records including extra- and intraoral photographs, full X-ray status, vinyl polysiloxane impressions of the dental arches including the alveolar processes and an exact bite registration.

The impressions are scanned by a computed tomography (CT) scanner while rotating in front of an amorphous silicon X-ray sensor. From the database a set of virtual models is generated. The precision of the scanning process is around 100µm (Lee et al. 2002). Eventual artefacts are corrected by a process of tooth shaping based on the operator’s knowledge of tooth anatomy and the patient’s photographs.

The occlusion is established based on the bite registration supplemented by the photographs, and a software program for collision control. In addition, the gingival sulcus is marked and a virtual gingiva is draped over the alveolar processes. This serves to define the margin of the aligners during manufacturing and to allow a more realistic
visual presentation (Fig. 17.1). Proprietary design software (Treat) subsequently enables the operator to separate the crowns of all teeth from each other (Beers et al. 2003).

Every individual tooth is checked for scanning artefacts by comparing it with the existing intraoral photographs, considering normal tooth anatomy. This process is called ‘tooth shaping’. In a subsequent operation termed ‘staging’, the software technician defines specific landmarks on the enamel surface to construct reference lines, e.g., the facial crown axis. The technician will then rearrange all the teeth according to the treatment plan submitted by the orthodontist and determine the sequence by which the individual teeth should be moved (Miller and Derakhshan 2002).

The two basic approaches are:

- Simultaneous movement of a group of teeth, called X-pattern due to its graphic representation
- Sequential movement of individual teeth as typically in a situation in which posterior teeth are distalized and where the movement of the second molars is followed by the first molars, the second premolars etc., named Y-pattern due to its graphic representation.

During all the movements, occlusal or interproximal interferences should be avoided. Within each stage, the movement can be variously programmed between 0.10 and 0.33 mm. Depending on the complexity of the malocclusion, the sequence and the velocity of movements, the number of necessary aligners required can reach 70 or even more.

After being prepared in the Align laboratory, the virtual model is sent to the clinician, who can assess the treatment with an animation program called ‘ClinCheck®’. If both clinician and the patient find the simulation satisfactory, the clinician clicks ‘accept’ to let the company know. Patients generally appreciate active participation in their therapy.

Once the treatment goal has been accepted, Align Technology will transfer the virtual model into a physical resin model using a stereolithographic method (Fig. 17.2). During stereolithography, a laser cures liquid polymer by photoactivation. The cleaned and refined acrylic models will then be loaded into an automat that heats, pressure forms and laser marks all the raw aligners, which are then transferred to a cutting automat. This machine will trim aligners after which they all are separated from the stereolithographic model, polished, disinfected, packaged and finally shipped to the respective doctor (Wong 2002; Kuo and Miller 2003) (Fig. 17.2).

What are the pre-treatment considerations?

Patients frequently arrive in an orthodontic office with the request to be treated with an invisible appliance. In this situation, they can be offered lingual appliances or Invisalign therapy. Principally, Invisalign therapy is orthodontics with just a different appliance system. Therefore, consultation, record collection, documentation of existing problems and treatment goals should follow standard orthodontic opera-
What characterizes patients seeking Invisalign treatment?

The chief complaint of patients choosing treatment with the Invisalign System includes crowding or spacing, flaring, supra- or infra-erupted teeth (Vlaskalic and Boyd 2001; Meier et al. 2003) (Fig. 17.3). Spacing and flaring can generally be resolved without problems and intrusion of over-erupted teeth is not a problem as long as the aligners are not dislodged occlusally from the anchor teeth. Retention can be easily improved by adding so-called attachments to the neighbouring teeth. Since extrusion of infra-erupted teeth cannot be predictably accomplished with the Invisalign System alone it may require additional measures (see ‘How can complications during treatment with the Invisalign System be avoided?’). Crowding can be treated by: interproximal enamel reduction (IER), expansion of the dental arch, moving posterior teeth distally or with extractions.

How does the Invisalign System differ from conventional orthodontics?

One of the biggest differences is that Invisalign treatment has to be planned from the first to the last movement in all possible details. In contrast to most other treatment modalities, the sequence, the direction and the amount of any tooth movement can only be changed by a midcourse correction (see ‘What can be done if during treatment a severe discrepancy between ClinCheck® and the clinical situation becomes evident?’), which implies additional costs and a delay of progress. This may seem to be disadvantageous, but can also be considered a challenge. The visualization of the anticipated outcome is helpful. Such visualization can be accomplished by using occlusograms (Melsen 2012), a standard study model set-up, or, as in the case of Invisalign, by a virtual set-up.

What is the most favourable approach to resolving crowding in Invisalign patients?

Crowding is most frequently resolved by IER, primarily because many Invisalign patients had orthodontic treatment previously, specially if the crowding is only moderate (Miethke and Jost-Brinkmann 2006) (Fig. 17.4). Extractions would create excessive space and IER is effective in avoiding open gingival embrasures (Atherton 1970; de Harfin 2000; Kurth and Kokich 2001; Zachrisson 2004), a problem which increases with age especially in patients with advanced periodontal diseases. IER is also the treatment
Since extraction therapy with Invisalign treatment is still controversial, it will be dealt with in a separate section below.

**What are the problems related to resolution of crowding?**

The malocclusion features related to crowding are labioluminal malpositions, rotations and deviations from normal angulation. Positional irregularities do not create any difficulties as correction usually only requires tipping or small bodily movements.

While rotations of relatively flat teeth such as incisors do not pose a problem, rotation of relatively cylindrical teeth as canines and premolars cannot generally be resolved with standard aligners. Any aligner which is programmed to derotate one of those teeth by no more than 2° will only contact the tooth surface in a few spots and most likely deliver more vertical than rotational forces (Fig. 17.5).

Rotation of molars is also a problem due to resistance by the root surface to such a movement.

Correction of angulations may also be a problem. It is easy to envision that it is difficult for an aligner with its smooth surface to move a tooth with a likewise smooth surface and hardly any natural undercuts. This problem can be overcome by bonding rectangular attachments to the respective teeth.

**When are extractions indicated?**

Since basic orthodontic principles also apply to Invisalign, indications for extractions are no different for these treatments. When extractions of premolars (Fig. 17.6) are indicated, although such extraction spaces could be closed with aligners, paralleling the roots of all teeth would be difficult, especially in a mandibular arch with a deep curve of Spee.
**Fig. 17.5** (1) Graphic representation of the fit between tooth and aligner. If the tooth is rotated 15° anticlockwise the aligner (white mesh) contacts the enamel only in the areas indicated by the red arrows, whereas it stands away from the remaining tooth surfaces. Please notice that the average rotation programmed by Align is between 2–5°, which results into a mean 0.2 mm movement of the distal/mesial proximal surface depending on the mesiodistal width of the respective tooth. (2) The result of the imperfect fit is a premature contact which could eventually lead to a completely different movement (intrusion) than originally intended (rotation); notice the extensive void areas between the aligner (white mesh) and the tooth.

**Fig. 17.6** Same patient as depicted in Figure 17.1; occlusal and lateral views before (1–4) and after treatment (5–8) involving extraction of maxillary first and mandibular second premolars; 46 aligners were used in the maxilla and 49 in the mandible. The result is satisfactory apart from some mesial tipping of the molars. This may be improved during case refinement, which would require additional aligners manufactured using either original or new impressions.
Extraction of mandibular incisors is only indicated if the lack of space exceeds 5.0 mm. It may be difficult to parallel the roots, and a midline discrepancy between the two dental arches will remain (Fig. 17.6). The main objection to extractions, especially in adult patients with a certain degree of gingival recession, is that removal of teeth will almost inevitably lead to open gingival embrasures (Fig. 17.6). Extractions should be considered as the last choice for resolution of crowding during therapy with the Invisalign System, and such treatment may require the use of appropriate attachments and even specific adjuncts (Miller et al. 2002).

Does an Invisalign treatment plan differ from a regular orthodontic treatment plan?

The answer to some degree depends on the school of thought to which the orthodontist belongs. Frequently, a standard treatment plan for removable or/and fixed appliances only comprises a general treatment outline, with no specification of any individual mechanical approach.

In the case of the Invisalign System, it is advisable to be as specific as possible. This is to some degree guaranteed by the fact that the orthodontist is expected to go through a six pages long treatment planning form which will not allow moving to the next page before every aspect of the current page has been sufficiently covered. Several pages have spaces for additional comments. The orthodontist can define:

- The order in which the treatment should be started (maxilla versus mandible).
- The sequence in which the individual teeth have to be moved.
- How many teeth are to be moved at a given time (active versus passive units).
- The movements in millimetres (0.10–0.33 mm) or in degrees.
- The type of movement (tipping versus bodily movement).
- Shape/size/number/position of attachments
- Inclusion of overcorrections required (in millimeters and degrees).

As far as overcorrections are concerned, the orthodontist has to make sure whether they are possible or will lead to occlusal interferences and thus instability.

How does one take an adequate impression for the Invisalign System?

The only impression compound acceptable at this point is vinyl polysiloxane, so-called a-silicone. The main reasons are that this is the only material that reproduces details with enough precision (<3 µm) and adequate long-term dimensional stability (~3 months). The impression is taken in a two-step procedure following the guidelines below:

- All impressions must be taken with perforated plastic trays supplied by Align Technology (Fig. 17.7). They
come in different sizes and can be customized by trimming them with a bur, by reshaping them under heat or extending them with the heavy-bodied component of the impression material.

- Severe undercuts, for instance bridges, must be blocked out with wax.
- Any material must be handled according to the manufacturer’s specification; components of different product families should not to be mixed with each other.
- Contact between impression material and latex (gloves) should be avoided.
- The first, heavy-bodied material impression should include all the teeth with all their surfaces and the surrounding alveolar processes.
- Space for the light-bodied material is created by blocking out the teeth and the alveolar process of the study model with a sheet of wax approximately 2 mm thick before the impression is taken on the cast (Fig. 17.7).
- Still, the heavy-bodied impression should be checked in order to verify whether there is enough space for the light-bodied material, i.e. the heavy-bodied material is not in contact with any teeth or parts of the alveolar process; if this is the case the heavy-bodied material must be trimmed away.

All of the above-listed procedures can be performed on the patient’s study model to shorten chair time.

- Before the tray with the light bodied material is inserted in the mouth all teeth have to be thoroughly dried.
- The light-bodied material is injected bubble-free into the impression tray and some extra material is dispensed over the teeth, especially on the distal surfaces of the terminal teeth.
- After the light-bodied material has set, the impression should be removed with a quick snap because slow removal would lead to unacceptable distortion.
- The subsequent inspection should reveal no voids/bubbles (Fig. 17.7). A perfect impression will replicate all tooth surfaces including the interproximal spaces and the adjacent alveolar process in all details. The heavy-bodied material should not show or only slightly show through the light-bodied component to avoid distortions.
- Finally, a bite registration has to be taken preferably also with a fast-setting vinyl polysiloxane.

The main disadvantage of a-silicone impressions is that they are costly – at least in comparison to standard alginate impressions.

**What is required to be evaluated in ClinCheck®?**

About 1–2 weeks after all necessary records are submitted, the orthodontist will be informed, on his personal VIP (Virtual Invisalign Practice) site, that the ClinCheck® is ready for inspection and possible acceptance. The first step of the evaluation should ensure that the morphology of all teeth and the occlusion reflect the correct intraoral situation. An improper occlusion of the virtual model can for instance indicate an impression failure (Fig. 17.8)).

The orthodontist should then compare his/her treatment plan including any annotated remarks with the virtual treatment plan. There may be differences either because the IT technician overlooked some information or realized during the virtual set-up that interferences, which could impede with the progress of treatment, had occurred. If the treatment plan has to be modified, the ClinCheck® is rejected. It is then altered until it is acceptable to the orthodontist and eventually the patient. Acceptance will be followed by production of all the aligners and a subsequent invoice.

Every ClinCheck® is supplemented by a reproximation chart, an attachment form and a sheet with general comments, which likewise ought to be checked. The reproximation chart will indicate how much enamel needs to be removed at which specific stage according to interferences detected by the software (Fig. 17.8). The attachment
Fig. 17.8 (1) Frontal view of a patient with an open bite before treatment with the Invisalign System. (2) Frontal view of the respective ClinCheck®. Note difference in severity of open bite, which is due to a deviation in the bite setting, but also may be due to an incorrect impression technique. (3) Reproximation chart of a patient in whom IER of 0.7–0.9 mm was suggested possibly due to the presence of interferences. According to Shillingburg and Grace (1973) the enamel thickness between both maxillary central incisors, between the central and lateral incisors and between lateral incisors and canines allows on average only 0.6 mm IER. Only with an orthoradial periapical radiograph can the individual enamel thickness be quantified to permit for more IER. In this patient the ClinCheck® was rejected and re-formulated.
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between the aligner and the tooth to be moved. The consequence could be an unwanted movement, as for instance intrusion. Therefore, such so-called less predictable tooth movements should at best be dealt with separately (see 'How can complications during treatment with the Invisalign System be avoided?).

As mentioned before, the efficacy of any aligner depends on a firm fit to every tooth surface. Since this is difficult to accomplish in flat teeth with a minimum of undercuts, e.g. mandibular incisors, or when there is an extrusive counter force that acts to dislodge the aligner during attempts to intrude teeth, the retention of the appliance should be improved by application of so-called attachments.

What material are aligners made of?

Aligners are made of 0.75 mm thick foils composed of polyurethane with methylene diphenyl diisocyanate and 1.6 hexanediol (EX 40). This material has sufficient visco-elasticity to allow some elastic deformation. The actual force system has as yet not been evaluated (Boyd and Vlaskalic 2001), but seems to be within physiological range on the basis of the following three observations:

- The amount (in mm) of every tooth movement is well defined and can be tailored to the assessed periodontal condition of each individual patient.
- Aligners are not fixed appliances and thus they can be taken out of the mouth to periodically allow the periodontium to recover.
- Final radiographs do not reveal excessive root resorption.

Theoretically, aligners contact all tooth surfaces and thus they should allow all types of tooth movement, even root movements and rotations. However, because the elasticity of the material is limited, premature contacts can occur between the aligner and the tooth to be moved. The consequence could be an unwanted movement, as for instance intrusion. Therefore, such so-called less predictable tooth movements should at best be dealt with separately (see 'How can complications during treatment with the Invisalign System be avoided?).

As mentioned before, the efficacy of any aligner depends on a firm fit to every tooth surface. Since this is difficult to accomplish in flat teeth with a minimum of undercuts, e.g. mandibular incisors, or when there is an extrusive counter force that acts to dislodge the aligner during attempts to intrude teeth, the retention of the appliance should be improved by application of so-called attachments.

What are aligner attachments?

Aligner attachments are small custom-made composite additions, which are bonded onto selected teeth. There are two types of attachments: ellipsoid and rectangular. Ellipsoid attachments are 3.00 mm long, 2.00 mm wide and 0.75 mm high, rectangular attachments are 2.00 mm wide, 0.50 or 1.00 mm high and 0.30, 0.40 or 0.50 mm long (Fig. 17.8). Both attachment types can be placed parallel to the long axis of the tooth or parallel to the occlusal plane. They can be attached to the buccal as well as to the palatal tooth surfaces. As a norm, the orthodontist should decide where which type of attachment should be placed.
For novices, it might appear difficult to decide about all these aspects. However, decision-making can be facilitated by comparing Invisalign treatment with fixed appliances therapy where it has to be decided whether a bracket on a specific tooth is needed. In general, appliance retention is enhanced significantly with the addition of attachments. Too many attachments will, however, complicate aligner removal from the acrylic model during production as well as from the dentition later during treatment. Still, sufficient attachments should be included in the plan since they cannot be added later on. Not every virtual attachment has to be fabricated in the patient’s mouth, at least not initially. Because of the system’s versatility, it is possible to bond a programmed attachment at any stage of therapy.

The need for attachments is less for teeth with sufficient undercuts, for instance teeth with long crowns, whereas they are definitely needed in patients who have short clinical crowns and shallow undercuts. If a doctor is uncertain regarding attachments he/she can talk to the Align customer agent who may suggest useful attachments.

How are attachments fabricated on the teeth?

The actual fabrication is assisted by a so-called thin shell template, which is a 0.25 mm thick aligner with respective concavities. These are loaded with a strong light-curing micro-filled composite, preferably one that comes in various tooth colour shades. The tooth surface has to be prepared as for a typical acid etch bonding procedure. The loaded attachment template is carefully placed onto the teeth (Fig. 17.8); the tray is firmly adapted with e.g. a ball end burnisher (Fig. 17.8) and finally all attachments are light cured. After polymerization, the template is carefully removed and the excess composite material is ground off with an appropriate finishing bur (Fig. 17.8). After this clean-up, the attachment should be well defined.

Attachment bonding is facilitated when it is done after the first aligner has been worn intensively for about 1 week (Fig. 17.8). Then, all teeth will be slightly mobile, which enhances the adaptation of the bonding template. Further, the patient is by now sufficiently adept at handling his/her aligner effortlessly and so the risk of damaging an attachment or an aligner is minimized.

If an attachment is lost or damaged during treatment, it can be refitted. This can be accomplished with either the current aligner or the respective part (tooth) of the original thin shell template. If the respective area is cut out, the attachment can be bonded to a specific tooth. The same course of action should be followed if an attachment was not fabricated initially but seems to be needed later on. In addition, if many attachments have to be placed, it might be practical to cut the thin shell template into segments to facilitate the bonding.

What has to be controlled after insertion of aligners?

Before the insertion, the aligners are briefly immersed into water to counteract their hydrophilic nature. Afterwards, the orthodontist will check whether the aligner can be inserted and taken out with adequate force thus avoiding distortion or damage. In addition, the aligner fit is controlled and demonstrated to the patient using a hand mirror. The fit is acceptable if all teeth are fully covered by the aligner material. Further, no gingival impingement should be noticeable. Finally, all margins should be smooth and fit close to the alveolus (Miethke and Vogt 2005) (Fig. 17.9).

In any case, the patient is given wax to protect against sharp edges or roughness detected later on; chewing gum may be used instead of wax. Before leaving the office, the patient should be taught:

Fig. 17.9  (1) Intraoral situation immediately after insertion of first aligner. Obviously, the aligner margins in certain areas are not as close to the alveolus as should usually be the case. A possible explanation could be that the volume of the gingiva decreased, although this is unlikely. Another possibility could be impression inaccuracy. In any case, the edges must be smoothened; subsequent aligners have to be checked for the same problem. (2) Clinical situation after nine aligners. The intended distal movement and derotation of the maxillary right lateral incisor did not occur as indicated by the void between appliance and tooth surface. It was planned to gain the necessary space for derotation by correcting the rotations of the posterior teeth on the right side. Since these movements failed, the alignment of tooth 12 also fell short. (3) In this clinical situation, neither could tooth 42 be proclined nor could tooth 41 be derotated because with the Invisalign System, teeth can only move in a straight line. The bend in the course of the dental floss indicates clearly that the path of movement is impeded, i.e. IER should be performed.
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down smoothly and in a straight line without any bend, the path of movement is unimpeded, i.e. the intended movement can occur (Fig. 17.9).

What are the consequences of good or poor aligner fit?

The presence of saliva bubbles between the tooth and the inner aligner surface (Fig. 17.10) indicates an inadequate aligner fit. Other indications are: void spaces predominantly occlusally/incisally and – after attachment bonding – discrepancies between these composite shapes and the respective aligner concavities. Such incongruities become evident especially to the patient if the attachment is marked before the aligner is replaced (Fig. 17.10). In case of poor aligner fit, the cause must be detected. Most likely, it will be lack of patient cooperation or lack of tooth movement. In the latter case, almost certainly it will be a movement which is considered less predictable within the Invisalign System (Joffe 2003; Miller et al. 2003; Miethke and Vogt 2005).

Examples of such movements are:

- Rotations of cylindrical teeth
- Extrusions
- Translations over larger distances e.g. after extractions of premolars
- Pure root movements.

The phrase ‘less predictable’ indicates that it is dubious that such movements can be generated. If a lack of space is the likely cause of improper aligner fit, IER is performed and the aligner is worn for another week or even 2 more weeks. Extension of appliance wear is also prescribed if poor cooperation led to reduced aligner fit. It should be kept in mind, however, that continued wear of a specific aligner is not the correct solution to this problem because the physical properties of the material change as it ages (Schuster et al. 2004; Eliades and Bourauel 2005).

If after use of several aligners, some teeth seem to lag behind others, this should not be ignored. Three alternative

- How to remove and insert the aligners with the same ease as the orthodontist,
- How to clean the aligners thoroughly at least once a day, preferably with a brush with long bristles,
- How often the aligners have to be worn. Principally, that is as close to 24 hours/day as possible, i.e. all the time except when brushing the teeth, eating and drinking any fluids that might stain (for instance red wine) or sugar-containing liquids.

The advantage of the appliance being removable may also be a disadvantage because patients may not follow the prescription (Boyd et al. 2000). To minimize this problem patients must be motivated again and again (Nedwed and Miethke 2005) along with cautioning about the possible lengthening of wear of every single aligner up to 4 weeks.

On an average, aligners are changed every 2 weeks (Owen 2001; Bollen et al. 2003; Clements et al. 2003). When the patient returns for his/her second visit about 14 days later, the fit and the cleanliness of the appliance are checked. At the same time, the patient is requested to give a report on his/her experiences and any inconveniences in relation to the Invisalign treatment. On the patient’s ClinCheck® the doctor can see which tooth/teeth in which plane of space will be moved with the second/third, etc. aligner (Fig. 17.9). Also, the reproximation chart, the attachment form and the comment sheet should be checked for any necessary interventions.

The procedure described above should be followed at all subsequent appointments. The reproximation chart might recommend IER at a specific stage due to an overlap of two adjacent teeth, as calculated by the software; however, this interference may only be virtual. Therefore, the orthodontist should verify a lack of space intraorally first, because indiscriminate IER can lead to unwanted gaps between the teeth at the end of treatment. The safest way of finding out whether enough space for tooth movement is available, is to take a piece of dental floss and push it between the two teeth that are possibly overlapping. If the thread glides down smoothly and in a straight line without any bend, the path of movement is unimpeded, i.e. the intended movement can occur (Fig. 17.9).

Fig. 17.10 (1) Most likely, the main cause for the poor fit of these aligners is that they are too short and do not cover the clinical crowns sufficiently. Therefore the programmed movements did not occur. The two most plausible explanations for the improper fit of the aligners are an impression error or a miscalculation during the virtual definition of the cemento-gingival junction. Retraction of the gingiva or reduction of its volume due to healing following inflammation is rather unlikely in a 22-year-old female patient with a good oral hygiene. (2) For illustrative purposes, the attachment on tooth 13 of this patient was painted red. (3) The respective concavity in the aligner was coloured blue. After insertion of the aligner, the discrepancy is obvious.
actions may be taken: first, every previous aligner should be tested in reversed sequence until the one that fits best is found. From there on, the treatment would restart with a respective lengthening of its duration. A second alternative could be to choose a so-called midcourse correction, a procedure, which will be described in detail below. Midcourse correction might include modified treatment goals. Thirdly, adjuncts such as buttons on the aligners for power-chains or elastics could be introduced to move the lagging tooth until it is most perfectly aligned within the patient’s present aligner.

If at the second appointment, the first aligner fits well, the second one is handed out to the patient maybe together with the third one. Hence, the patient can change aligners without visiting the doctor’s practice. If after 4–6 weeks, the third aligner is fitting satisfactorily, the fourth, fifth and sixth are delivered to the patient. Though the patient will appreciate savings of time by not having to see the doctor for every aligner insertion, it is not advisable to deliver more than two aligners for independent change. Leaving the patient with more than two aligners, may result in the treatment getting out of control even when the patient seems to have a full understanding of the therapy.

What if an aligner is lost?

The answer depends on how soon after the loss the patient sees his/her doctor and how long the aligner was worn up to this point. If the patient shows up soon enough, there are two possibilities: one is to assume that the lost aligner had accomplished almost all programmed movements because the wearing time was sufficient. In that case, the patient receives his/her next aligner, which might fit tighter than normally and should be worn a little longer than usual. The second option is to order a replacement for the lost aligner from Align Technology. This is unproblematic because all necessary data exist in the patient’s Treat software. Until the substitute aligner is delivered within approximately 2 weeks, the patient is put ‘on hold’, i.e. he/she receives an ad hoc made retainer, preferably of the same make as the lost aligner, or he/she wears the previous aligner. To cover this possibility, it is mandatory to keep all used aligners, which is best guaranteed if the orthodontist keeps them.

If a longer period has passed and the patient did not have the previous aligner at the time of loss, it can be assumed that a partial relapse has occurred. The doctor should try to find the best fitting aligner out of all the aligners that the patient has worn in the past and then progress as described previously. In the meantime, the lost aligner could be reordered or it could be attempted to ‘jump’ from the aligner used before the lost one to the one following it. Another alternative would be to start a midcourse correction, which is dealt with in the next paragraph.

What can be done if a severe discrepancy between ClinCheck® and the clinical situation becomes evident during treatment?

In case of a discrepancy between ClinCheck® and the clinical situation, a so-called midcourse correction is indicated. Such a ‘reboot’ is similar to starting a new patient. It means that all the above-listed records must be taken again and submitted to Align Technology together with a new treatment plan. Most probably, the course of treatment and/or its goals will need to be changed because there was a clear reason why the first approach failed. Overall, a midcourse correction requires extra time, efforts, and costs. To limit the financial loss, Align Technology offers a type of insurance to cover a restart.

What can be done if a slight discrepancy between ClinCheck® and the clinical situation becomes evident at the end of treatment?

In this situation the so-called case refinement is indicated. Case refinement implies that even though all aligners were worn, not every one of the intended movements has materialized to the patient’s and/or doctor’s satisfaction. In this case, generally new impressions have to be submitted, supplemented by respective special instructions; current intraoral photographs would be advantageous. Case refinement might also be considered to counteract an apparent relapse tendency. Under these circumstances, no new impressions are needed because the original ClinCheck® can be used to fabricate additional aligners to accomplish the respective overcorrections.

How can complications during treatment with the Invisalign system be avoided?

The three most common causes for complications are lack of space and cooperation as well as non-occurrence of less predictable tooth movements. Space problems are easy to resolve with IER. In contrast, lack of cooperation cannot always be foreseen and thus remains a possible risk. Finally, difficulties with less predictable tooth movements can be anticipated and they should be dealt with while developing the treatment plan for a given patient. As rotations of cylindrical teeth pose a problem, there are four possible options to overcome it. Derotations can be:

- Accomplished before Invisalign treatment (Fig. 17.11),
- Programmed for the first stages of Invisalign therapy,
- Programmed for the last stages of Invisalign treatment (Fig. 17.11),
- Dealt with after Invisalign therapy is finished (Fig. 17.11).
Fig. 17.11 (1–4) This patient was previously treated orthodontically with extraction of both first premolars on the left side. Her chief complaints were bimaxillary crowding, large overjet and maxillary midline deviation. She refused any correction of the malocclusion features on the left side. Since derotation of tooth 33 was less predictable, it was decided to accomplish this before aligner treatment. Therefore, the patient received a custom-made splint with two hooks (5). It would have been preferable to place the hook next to tooth 42 on the lingual side because the labial position would lead to some buccal displacement. The treatment was finished to the patient’s satisfaction (6–9). To assist derotation at the end of treatment, detailing pliers can be used to introduce pressure points by deforming the aligner material (10). One arm of the pliers has a pointed tip of a different size while the other arm has a hole. When the arms are pressed together, the semi-rigid material will be forced slightly into the hole, producing a concavity. This activation can assist in accomplishing movement not expressed by the aligner alone. Careful activation requires slight heating of the pliers.
Fig. 17.11  (11,12) This patient’s chief complaint was bimaxillary crowding. (13) Uprighting and rotating tooth 33 is to be considered a less predictable movement. (14) The situation after Invisalign treatment. At that time tooth 33 needed more uprighting, some extrusion and minimal lingual tipping. To solve all these problems within a reasonable timeframe, a ceramic bracket was bonded to tooth 33 and a customized splint inserted in which a tube in the region of tooth 36 was embedded. A cantilever extending from tooth 36 to tooth 33 was used to perform the correction. The patient was supplied with some hemostats so she could ligate the cantilever into the bracket with an elastic. Thus, the appliance was removable while this treatment phase was rather invisible at the same time. The treatment was finished to the patient’s satisfaction (15–17).

Fig. 17.12  Pretreatment study model of a patient with bimaxillary crowding, crossbite on the left side and between the teeth 12, 43; note the differences in the level of the incisal edges of the maxillary central and lateral incisors (1). This difference increased significantly after correction of the crossbite by expansion of the maxilla and correction of the bimaxillary crowding by protrusion of all front teeth (2). To resolve this problem predictably some clear buttons were applied on the labial surfaces of the lateral incisors close to the gingiva. After imitation of the intended extrusion on a set-up model an aligner-like splint was fabricated with two pairs of hooks on the palatal side (3). Elastics facilitated a predictable extrusion with forces which could be adjusted freely by choosing different elastics. Situation after the intended extrusion was completed (4).
Derotation during the first stages of Invisalign treatment seems questionable because if it does not materialize, a midcourse correction becomes necessary, which likely challenges the confidence and patience of the affected patient. If derotations are postponed to the final stages and are not accomplished, the patient might develop the same negative reactions as described above.

Thus, it seems to be best to discuss such a problem with the patient before Invisalign treatment is initiated and to correct less predictable tooth movements before Invisalign therapy. This could mean using a few (clear) brackets and cantilevers to achieve the necessary positional change. Another possibility could be a combination of a clear plastic splint retainer with Class I elastics attached to any kind of adjuncts, such as buttons, cleats, etc. (Fig. 17.12) on respective teeth (Vlaskalic and Boyd 2002; Boyd 2005).

In any case the orthodontist must draw on his/her creativity to deal with any movement that might not be generated by Invisalign therapy, thus satisfying the patient’s expectations to be treated with an invisible appliance.

References


