

A discerning approach to simple aesthetic orthodontics

J. H. Noar,^{*1} S. Sharma,² D. Roberts-Harry³ and T. Qureshi⁴

IN BRIEF

- Considers the treatment planning issues required in aesthetic orthodontics.
- Helps the practitioner make a critical assessment of the suitability of a patient for sectional orthodontics.
- Highlights the use of arch evaluation and digital printing for a predictable outcome.
- Looks at the development, uses, advantages and disadvantages of clear aligners.

There is currently considerable interest from general dental practitioners (GDPs) in the use of simple orthodontics to treat adult malocclusions. There is controversy in this, particularly in relation to 'quick fixes', simple orthodontics and 'straight teeth in six months' as opposed to more conventional treatment where the whole malocclusion is treated. This article will present a case for the use of simple aesthetic adult orthodontics in a measured and planned way. It will discuss the processes, planning and the importance of consent. It will also highlight how digital technology is used to preview, consent and execute an aesthetic result. Many of the recent systems emerging, have been as a result of the demand and supply of cosmetic dentistry. This, to a degree, has not helped since the implication of a 'quick-fix' is associated with this field. There has also been discussion on what the limits of GDP orthodontics should be. There is variability in how GDPs approach orthodontics, their experience, skill and ability to treat to an acceptable standard. Short courses may be one way of delivering orthodontic training but some of these courses are not regulated and the amount of internal mentoring is variable. This article highlights some of the systems in use, and potential upsides and downsides of this approach.

INTRODUCTION

There is growing availability, publicity and knowledge on the benefits of orthodontic treatment and quick cosmetic corrections with short orthodontic treatment are becoming ever more popular. With the development of aesthetic, low-profile, self-ligating and conventional bracket systems, there is more tolerance and acceptance of fixed appliances by adults. The advent of lingual appliances and 'invisible' aligners has also made the concept of orthodontic treatment more acceptable to many adults. A questionnaire-based study suggested that adults are commonly concerned with the appearance of orthodontic appliances.¹ The low profile systems associated with short orthodontic treatment are therefore an attractive option for adults and can very successfully satisfy a specific need.

However, there are two issues that have to be understood and these facts are now accepted by most who treat orthodontic patients. First, orthodontic cases, however well treated, are prone to relapse and some features are more prone to relapse (rotations, deep bites, open bites, spacing) than others. Second, teeth move throughout life and even if there has been no orthodontic treatment teeth will move and features such as crowding will worsen.² It is this fact that is often missed and as a consequence extensive restoration of dentitions can fail because of these natural changes, such as a decrease of the inter-canine width with significant occlusal changes.

How many dentists who see mild/moderate crowding in their patients every day are telling them that their teeth will get worse? These statements are why more adults are seeking treatment but they are different to a child seeking treatment at the age of 11. Adults often present with a mixture of complaints which may be associated with dental and facial aesthetics, as well as function. These include concerns regarding crowding, spacing, gingival recession, tooth wear and tooth discoloration. Patients may also express concerns about black gingival triangles, lip traps, trauma, cheek biting and the prognosis of compromised teeth.

Many will seek a cosmetic solution for these issues without wishing for active

treatment or perfection in terms of a functional occlusion. Addressing the cosmetic concerns of an adult patient with short orthodontic treatment is completely legitimate, providing this option is presented in addition to all other viable restorative and comprehensive orthodontic options.

The pros and cons of short-term orthodontics and what is considered to be good ethical practice has been debated in recent articles by Chate³ and Maini.⁴ There are specific considerations that should be borne in mind when treating adult patients with short-term orthodontics and this includes what constitutes valid consent.

Before considering whether or not short orthodontic treatment is an appropriate modality of treatment, it is important to consider the challenges when treating an adult dentition. It is also crucial to take into account the patient's pre-existing functional occlusion, their expectations, and whether or not treatment can be delivered safely and effectively within a short timescale.

THE FUNCTIONAL AND AESTHETIC CONSIDERATIONS

Adult orthodontics is complicated by a lack of skeletal growth, which means orthodontic-only options depend on the precision of tooth movement to correct the malocclusion, camouflage an underlying skeletal discrepancy and support restorations. However, it is

¹Consultant /Hon Senior Lecturer Eastman Dental Hospital/Institute, Orthodontic Unit, Division of Craniofacial & Development Sciences, Eastman Dental Hospital/Institute, 256 Grey's Inn Road, London, WC1X 8LD; ²Post CCST Trainee, Eastman Dental Hospital and Ashford and St Peters Hospitals; ³The Roberts-Harry Dental Clinic, East Parade, Harrogate, HG1 5LB; ⁴Intelligent Alignment Systems, 178 Blackfen Road, Sidcup, Kent, DA15 8PT
*Correspondence to: Joe Noar
Tel: +44 (0)20 3456 1160; Fax: +44 (0)20 3456 1238;
Email: J.Noar@ucl.ac.uk

important to note that most adult occlusions are imperfect but stable, as they have been worn into a good intercuspal position with a few unstable occlusal interferences.

A patient's perception of their occlusion is not only a physical and anatomical one. It also relates to proprioceptive feedback. They may therefore complain of an 'unusual' or 'uncomfortable' bite as the teeth are moved away from their original positions. For this reason, adult patients who wish for a cosmetic correction must be made aware of how changes to their anterior or posterior occlusion may impact on their perception of a 'comfortable bite' – even if a good functional occlusal result is achieved. Complex upper and lower fixed appliance mechanics can significantly disturb the posterior occlusion and this can be very difficult to restore because of previous tooth wear. Most short orthodontic treatment typically involves the anterior six teeth in one or both arches, so changes to the posterior occlusion are minimal. But when short-term orthodontics is being undertaken to assist the provision of anterior restorations, it is necessary to consider if they will be adequately supported by the posterior dentition and protected from early failure. Furthermore, when teeth are being moved to accommodate complex restorations, such as implants and bridgework, fixed appliances must be used to achieve three-dimensional control of the teeth and root paralleling, which is difficult if using aligners alone.

Aesthetics is often a primary concern among those seeking treatment through short orthodontic treatment and there are several other factors relating to this that need to be borne in mind when treating the adult patient. Due to previous dental disease or tooth wear, some form of crown modification may be necessary in order to idealise the end aesthetic result. In some cases, interdental enamel reduction can be used to parallel teeth, reduce unsightly spaces that may occur either incisally or gingivally following alignment, or to create a minimal amount of space to manage anterior crowding. In these cases great care should be taken to ensure that the ideal proportions of the teeth are maintained and centrelines are coincident with the centre of the face to allow for ideal and optimal aesthetics.

The concept of a short orthodontic treatment can be seen as both a compromise and a simple solution to solve a presenting complaint. Whether or not short orthodontic treatments are considered to be a legitimate form of treatment will depend very much on each individual case and, more specifically, on the occlusal platform and objectives of the patient. Primary orthodontic

goals including a Class I occlusion with good buccal interdigitation and alignment are desirable. However, if patients concerns are exclusively related to the cosmetic appearance of their anterior teeth and a functional occlusion can be maintained, it is reasonable to suggest a short-term treatment option to avoid disruption to an intercuspal posterior occlusion or involvement of compromised posterior teeth. Indeed, in these cases, unnecessarily including compromised posterior teeth onto a fixed appliance can result in prolonged treatment times and unfavourable outcomes such as root resorption or further periodontal breakdown, even in more experienced hands.

Finishing with a slight overjet and expanding the dental arches does not imply that the quality of treatment is poor, providing the implications of this and, if necessary, the importance of lifelong retention are understood by the patient. Accepting compromises can be a legitimate part of limited objective orthodontic treatment, provided they do not lead to long-term consequences. Occlusal interferences which can lead to toothwear, TMJ dysfunction or damage to complex restorative work must be avoided. The patient should be provided with a written treatment plan, including any costs of the treatment. In addition, valid consent should be obtained and this should be carefully documented.

OBTAINING VALID CONSENT

Despite all the reasons supporting the objectives of short orthodontic treatment, there are drawbacks. The general risks that apply to those having routine orthodontic treatment would also need to be explained to those accepting short orthodontic treatment. These include the risks of decalcification, periodontal diseases, root resorption, devitalisation, decay and relapse. Any significant aspect of the occlusion that is to be accepted, for example, an increased overjet, should be recorded and included in the written treatment plan.

Adults often present with greater expectations than children. This, combined with the status of their periodontal and dental health, may present as additional complications. For this reason, while short orthodontic treatment may help obtain quick, aesthetically pleasing outcomes, it is prudent to consider joint consultations with periodontists and restorative specialists in certain circumstances.

If treatment involves multidisciplinary input, as part of the consent process, the roles of each treating clinician and the timing of their intervention must be defined and clear to the patient and clinicians involved.

Furthermore, if restorative intervention with veneer placements is being considered, the well documented risks associated with this,^{5,6} longevity of these restorations and the likely financial costs related to repairs and replacements should also be discussed and documented. Even if veneer placement is not anticipated from the outset, they could be used to camouflage a degree of relapse in the future and it would be wise to mention this to patients where appropriate.

For all orthodontic treatments a full assessment of the occlusion must be undertaken in order to plan carefully the anchorage requirements and ascertain if the underlying problems can be addressed with the appropriate use of mechanics without fulfilling all the occlusal objectives. One common source of patient/dentist conflict relates to the length of treatment. The short orthodontic treatment suggests that all treatment objectives will be met within six months or so. However, it would not be ethical to promote this without clarifying when and if treatment is likely to take longer at the time of consent and as treatment progresses. Failing to do so may raise patient expectations, which can be hard to reconcile.

Patients may seek short-term orthodontic treatment to address some mild crowding which has occurred as a result of late lower incisor imbrication, either due to soft tissue factors or post-orthodontic relapse. In these cases it may be possible to use restorative options, removable aligners or fixed appliances. From the outset, every patient must understand the responsibility they have to maintain the occlusal result and the importance of life-long retention. They should also be aware how relapse may be managed should it occur in the future. The failure rates of maxillary and mandibular fixed retainers are well documented,^{7,8} as are findings from studies which have shown that up to 27% of maxillary and 22% of mandibular retainers are lost within the first year of retention.⁹ In view of this, the cost implications of repairs and replacement retainers should be discussed along with any specific and anticipated modifications to the retention regime. For example, in the upper arch, placement of a permanent retainer may prove difficult in the presence of an increased overbite. In such cases, patients would need to be made aware that having a permanent retainer is not an option and they should therefore expect to wear a removable retainer to maintain the final treatment result.

With any form of dentistry that is addressing the aesthetic concerns of a patient, the essential ethical treatment planning issue is that of very careful objective setting. What a clinician and patient think is an



Fig. 1 (a) 8 mm crowding; unsuitable for simple treatment; (b) 1.8 mm crowding; suitable for simple treatment

acceptable outcome may differ, especially when short-term orthodontics is undertaken to 'perfect' smiles. It is therefore incumbent upon the practitioner providing treatment to be accurate, both in their description of the treatment and anticipated result. Specific treatment aims and objectives should be discussed based on the presenting malocclusion, complicating factors and the patient's wishes. These aims should be documented to ensure informed consent has been sought and the patient appreciates the limitations (if any) associated with a quick cosmetic correction. In order to empower patients with an ability to make an accurate assessment of the treatment being offered, it may be helpful to supplement any written and verbal information with a Kesling set-up and/or pictures.

The document *Professional standards for cosmetic practice*¹⁰ is aimed at all cosmetic healthcare professionals, including nurses and dentists who are involved in cosmetic treatments. It highlights these issues and indicates that the treating clinician should explicitly indicate if there are alternative treatment options and the consequences of doing nothing. The same document also highlights the importance of clinicians being honest and open with patients about their qualifications and experience.

'Short orthodontic treatment' is promoted as being effective and safe. In the right hands and in the right patients this can certainly be the case. When this treatment modality is being proposed as an option, clinicians should avoid treating patients as 'consumers' of a 'brand'. Short orthodontic treatment should only be offered if it is felt to be in the patient's best interests and the complexity of the malocclusion can be safely and well addressed to achieve a

specific set of treatment objectives within a limited timescale.

The treating clinician should be competent enough to critique the presenting occlusion and manage it through to its end result. They should also be able to appraise the pros and cons of all available options and have sufficient experience with fixed appliances. While courses on short-term orthodontics may well promise this, it is the treating clinician's fundamental responsibility to be aware of their own limitations and that they are accountable for any unfavourable outcomes that may ultimately result from insufficient training and experience. Discussions about the risks, benefits, alternatives, anticipated treatment time and proposed outcomes should be carefully documented at all times.

There are some obvious starting points for any GDP contemplating offering a short orthodontic treatment plan to a patient:

1. The patient should have an orthodontic examination
2. The patient must be offered the benefits of comprehensive treatment; understanding any compromises that might remain by not treating the whole mouth and a referral to a specialist should also be recommended
3. An arch evaluation (Fig. 1) should be carried out by the clinician to show understanding of the tooth position, the planned goal of treatment and what affect that might have on the anterior occlusion. Landmark and reference points should be used to ensure the occlusion is preserved or enhanced
4. A space calculation should be carried out from the arch evaluation which might eliminate some treatment options because of the degree of difficulty

of the case, so that once started, treatment cannot be completed. A space calculation could also justify the need for an extraction or not, thus eliminating the need for guesswork

5. A Kesling type setup or a 3D model of the proposed outcome may be useful and can be assessed with the patient before going ahead with treatment to assist with obtaining informed consent
6. If interproximal reduction (IPR) is required it should be carried out accurately according to the evaluation in a recorded, measured and progressive way to minimise excessive damage and poor contact-point anatomy
7. A life-long retention regime should be understood by the patient as mandatory before treatment begins
8. Cases that are too crowded or movements that are beyond the capability of a treatment modality or the competence of a practitioner should be referred to a specialist (Fig. 1).

CONTEMPORARY CLEAR ALIGNERS

The concept of moving teeth using aligner-type appliances is not new and clinicians have been using similar systems to align anterior teeth for decades. Unlike fixed appliances, which apply forces to *either* the labial or lingual surface of teeth, these systems can apply *simultaneous* forces to the buccal, lingual and occlusal surfaces of the teeth. One of the earliest examples is the Barrer appliance (Fig. 2)¹¹⁻¹³ where teeth are aligned on a plaster model and a removable appliance is constructed on this utilising buccal and/or labial springs to 'squeeze' the teeth into alignment.

John Sheridan popularised what is arguably the first clear alignment system made from vacuum formed Essix polyurethane plastic using his concept of 'windows and divots'.¹⁴ This technique and the Barrer appliances are relatively simple devices capable of only minor tooth movement.

In recent years the sophistication of aligner technology has improved dramatically and the popularity of these systems is increasing. There are many varieties of clear aligners and the market leader is Invisalign, manufactured by Align Technology based in San Jose, California. The company was founded in 1997 by two Stanford University MBA graduates, Zia Chisti and Kelsey Wirth, and in 1988 received FDA clearance. Commercial sales started in the USA in 1999 and in 2001 Invisalign were released to the European market. By 2014 Align had manufactured 148.7 million aligners, treated 2.6 million patients and posted net annual revenue figures of \$660.2 million.¹⁵

Invisalign straightens teeth using a series of nearly invisible, removable plastic aligners that are custom made for each patient. Each aligner is replaced every 2 weeks and the teeth move little by little towards the projected final position. The process starts by taking photographs and PVS impressions or an intra-oral scan of the teeth. Photographs, radiographs, scan and a treatment plan are submitted electronically through the Invisalign Doctor Website (IDS). The impressions are shipped to the Align factory in Juarez, Mexico. They are scanned using a CT scanner and these data transferred to the Invisalign Treat Facility in San Jose, Costa Rica, where a virtual 3D computer model is created. A technician then manipulates the model according to the treatment plan provided by the referring dentist to straighten the teeth. This completed 3D model is known as a ClinCheck, which the clinician can access via the IDS and request modifications as required. Once approved, the aligners are manufactured in Mexico and then shipped to the UK. This whole process takes about 6 weeks.

Attachments made from composite are often fitted to the teeth to assist with tooth movement. Once the aligners are fitted the patient wears them for 22 hours a day, removing them only for eating and cleaning. The patient changes the aligners every 2 weeks and returns to the clinician for check-ups at approximately 6 to 8 week intervals. At the completion of the initial phase of treatment another short course of treatment known as refinement may be required.

All aligners are essentially pushing devices and work best on teeth with broad flat surfaces such as upper central incisors. Thus, derotating central incisors and tipping teeth are easily achieved with these devices. However, there are inherent problems such as:

- Uprighting (mesio-distal root control)
- Rotating round teeth, such as premolars or small lateral incisors
- Rotating teeth tends to undesirably intrude them
- Torque (labio-lingual root control)
- Deep bite correction
- Teeth tipping into extraction sites.

Another issue is that plastics absorb water and as soon as the devices are placed in the mouth absorption begins with a resultant loss of elasticity. This typically generates high insertion forces, which then rapidly decay after only a few days. This does not produce efficient tooth movement, which works best with the application of continuous light forces.

To overcome these problems Align have made substantial investment into research

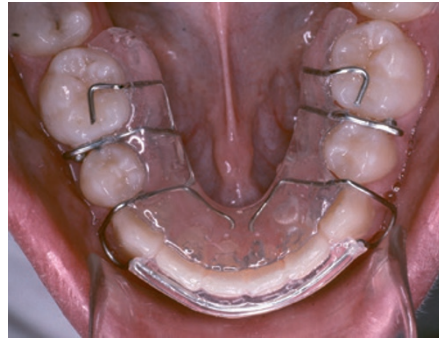


Fig. 2 An example of a Barrer type appliance where the anterior teeth are sandwiched between an acrylic covered labial bow and a lingual baseplate



Fig. 3 Optimised root control attachments

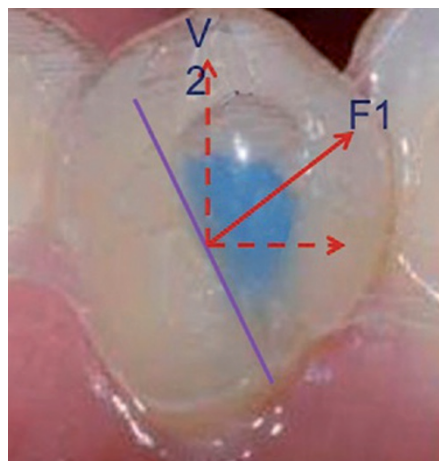


Fig. 4 Optimised rotation attachment. A force F1 is applied to the bevelled shape which produces a rotational vector V1 and an extrusive vector V2 that counteracts the unwanted intrusion

and development reported at some \$50 million per annum. This resulted in the development of a new aligner material (SmartTrack®), which is a multi-laminate polyurethane capable of producing a more continuous force over a longer period of time. This reduces the insertion force when the aligner is first fitted and the decay is much slower than with conventional plastics, akin to using a super elastic nickel titanium arch wire.

For many years Invisalign has utilised composite attachments to aid tooth movement. In the early stages these were rectangular, oval or round in design and relatively crude in terms of controlling tooth movement. A

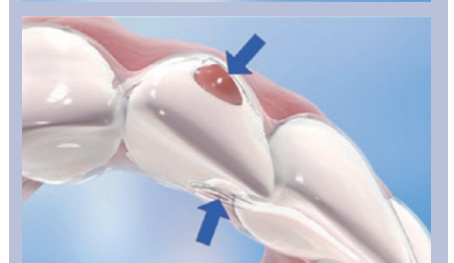


Fig. 5 Multi-plane movement feature for upper lateral incisors

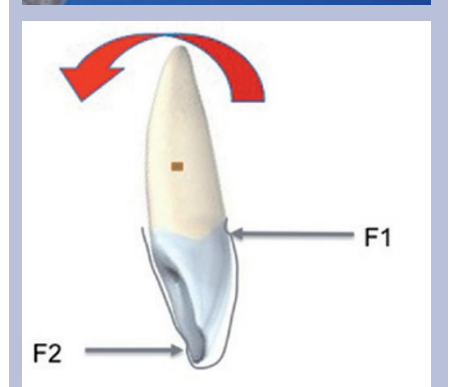


Fig. 6 The Power Ridge feature applies lingual root torque via an indentation near the labial cervical margin (F1). A palatal Power Ridge is only placed when both root torque and retraction are being performed on Clincheck (F2)

team led by John Morton a biomechanical engineer (known for his work with Charles Burstone^{16,17}) developed Invisalign G3, a set of innovations engineered to deliver better clinical results, with Precision Cuts designed to make it easier to treat Class II and III patients and SmartForce® features for more predictable tooth movements. Since then new SmartForce® attachments G4 and G5 have increase the predictability of tooth movement. As a consequence more complex cases can now be treated.

Uprighting teeth

Optimised root control attachments (Fig. 3)



Fig. 7 Pre-treatment photographs of a deep bite case

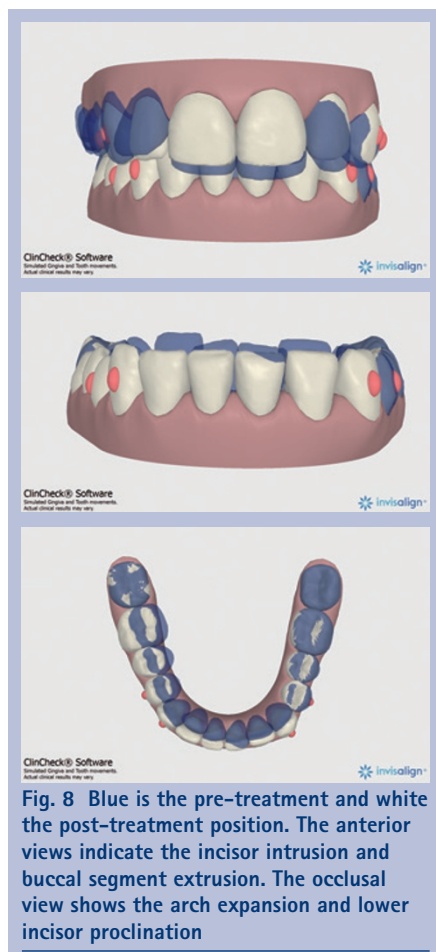


Fig. 8 Blue is the pre-treatment and white the post-treatment position. The anterior views indicate the incisor intrusion and buccal segment extrusion. The occlusal view shows the arch expansion and lower incisor proclination



Fig. 9 Completed case showing good overbite reduction

are designed to provide mesio-distal root tip control of canines, premolars and upper central incisors. These attachments provide multiple points of contact to create a moment that is favourable for the root movement. This feature is applicable for space closure, mesio-distal root uprighting, bodily movement and midline shift.

Rotations

Rotation attachments (Fig. 4) are customised for each tooth based on the desired movement, tooth width, long axis and contour of the crown. In this example as the tooth is rotated mesially the design of the attachment produces an extrusive vector that counteracts the unwanted intrusion.

Multi-plane movement feature (Fig. 5) is designed for the control of upper laterals undergoing extrusion along with rotation and/or crown tipping. The active surface of the optimised attachment is oriented to deliver extrusive forces while simultaneously rotating and/or tipping the lateral. A pressure point on the lingual aspect of the aligner applies a second force for control of the multi-plane movement. The active surface of the optimised attachment is oriented to deliver extrusive forces while simultaneously rotating and/or tipping the lateral.

Torque control

Power ridges (Fig. 6) are designed to produce a torque couple through a relatively larger force being applied by indentations near the labial cervical margin. A moment is created by a smaller opposing force indentation near the palatal incisal edge.

Deep bite

A deep bite is corrected by flattening the curve of Spee, which is achieved by molar/premolar extrusion, incisor/canine intrusion, incisor proclination and arch expansion. Invisalign treatment can utilise all four of these methods to correct a deep bite as illustrated by the case depicted in Figure 7 which features a Class II division 2 occlusion with a deep bite and with moderate upper and lower crowding. The Clincheck indicates the proposed tooth movements required for correcting the deep bite (Fig. 8). The superimposition of the pre- (blue) and proposed post treatment (white) tooth movements to achieve overbite reduction are indicated. The completed case is shown in Figure 9.

Align technology have introduced new G5 deep bite innovations with optimised extrusion attachments which are designed to further enhance deep bite correction.

Open bite

Fixed appliances tend to extrude the buccal segment making reduced overbite and open bites worse. Because aligners cover the posterior teeth there is a tendency to reduce this and, along with optimised extrusion attachments, this unwanted tooth movement can be prevented (Figs 10-12).

Controlling unwanted tooth movement

When full arch fixed appliances are fitted all the teeth start moving simultaneously. This can occasionally produce unwanted tooth movement, which can be difficult to correct as illustrated by the case shown Figure 13. This patient has a severe Class II division 2 incisor relationship on a Skeletal II base. In order to produce a Class I incisor and skeletal relationship, orthognathic surgery in conjunction with fixed appliances is needed. However, the patient did not want surgery and simply wanted her anterior teeth aligned. Attempting to do so with fixed appliances can result in a dramatic increase in the overjet, which is then difficult to correct. An alternative is a compromise treatment where the arches are aligned but some upper incisor retroclination is accepted. With aligners the movement of the upper incisors can be controlled



Fig. 10 A reduced/open bite case. These can be problematic with fixed appliance treatment as the bite tends to open as the buccal segments are extruded



Fig. 12 The completed case with an improved overbite



Fig. 13 A Class II division 2 incisor relationship on a severe skeletal II base. If fixed appliances are fitted the overjet will increase dramatically. With aligners the movement of upper central incisors can be restricted allowing the other teeth to be aligned around them

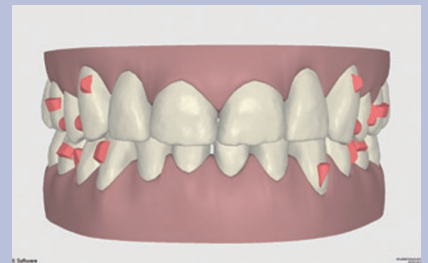


Fig. 14 The 3-D Clincheck simulation can run different treatment scenarios, assisting the patient in coming to an informed decision about which option to choose



Fig. 11 The ClinCheck showing beveled optimised extrusion attachments

allowing a compromised but acceptable treatment outcome.

ADVANTAGES OF ALIGNERS

The aligners are virtually invisible making this method particularly popular among adults and teenagers who want to straighten their teeth without the appearance of traditional fixed appliances.

They appear to be more comfortable with significantly less pain and discomfort than with fixed appliances, and patients require less pain relief.^{18,19} They are removable so patients can eat, drink, brush and floss as normal, which seems to reduce the risk of decalcification, and gingival and periodontal issues associated with fixed appliances.¹⁹⁻²¹

Some studies have suggested that Invisalign treatments are faster than fixed appliances.^{20,22} However, larger prospective randomised trials are required to substantiate these observations.

Both clinician and patient can view simulated treatment outcomes in the ClinCheck. Multiple treatment scenarios can be developed which is a powerful tool in treatment planning and providing informed consent (for example, Fig. 14). In this example the upper central incisor edges were worn and the gingival line was uneven. The options are to accept, extrude the incisors to level the incisal edges and accept the irregular gingival smile line, or intrude the incisors to level the gingival margins and then restore the incisal edges. These different ClinCheck options can be shown to the patient, and the advantages and disadvantages of each discussed.

DISADVANTAGES

Some tooth movements are still challenging and although the introduction of optimised precision attachments has helped, this problem has not been completely overcome. Extraction cases need careful handling because the teeth can tip into the extraction site and auxiliary

techniques such as sectional fixed appliances may be needed to correct this. Align are currently developing an extraction protocol which is due to be released early in 2015.

Unlike labial fixed appliances, aligners may cause a slight lisp at the beginning of treatment. This usually disappears within a



Fig. 15 Loss of tracking. The aligner is not fitting with a gap between the aligner and the upper incisors and canines



Fig. 16 Close view before treatment showing inter-canine collapse and crowding



Fig. 17 Immediately after alignment and whitening



Fig. 18 Seven years with retention post-treatment



Fig. 19 Side-view before treatment

few days as the patient becomes used to the aligners. Because they are removable, compliance can be an issue. Some patients find wearing aligners 20–22 hours per day difficult which can compromise the tooth movement leading to loss of tracking (Fig. 15) Also, because they cover the occlusal surface of the teeth there is a tendency to develop a minor lateral open bite. However, this is rarely an issue and the bite usually settles during the retention phase.



Fig. 20 Side-view after 9 weeks of treatment and whitening



Fig. 21 Side-view after 7 years



Fig. 22 Occlusal (a) before; (b) after 5 years

The 3D ClinCheck set up is a powerful tool prepared by technicians based in Costa Rica. It is important to remember that they are not clinicians and it is the responsibility of the referring practitioner to ensure that the proposed tooth movements are possible. It is tempting to review the ClinCheck and think that what you see is what you get but this is not necessarily the case. The treatment plan and planned movements must be carefully reviewed or the case may not be successfully treated and the patients expectations not met. All clinicians have a duty of care to ensure they have adequate skill and training to carry out orthodontic treatment. Careful case assessment, treatment planning, discussion about different treatment options (not just aligners) and adequate case management are important if problems are to be mitigated. It is important not to act outside one's field of competence with consequent risk of litigation or being reported one's professional body.

Aligners seem to be an effective system but there are few robust scientific studies to confirm or refute this. Some early studies were unable to draw strong conclusions about the effectiveness of the Invisalign system.²³ Other studies have produced conflicting outcomes^{24,25} Djeu *et al.*²⁶ concluded that Invisalign was especially deficient in its ability to correct large anteroposterior discrepancies and occlusal contacts. However, they reported that the strengths of Invisalign were the ability to close spaces and correct anterior rotations and marginal ridge heights. They also found that on average, Invisalign patients finished 4 months sooner than those with fixed appliances. Kuncio *et al.*²⁵ compared the treatment outcomes of Invisalign compared to fixed appliances using the objective grading system (OGS) of the American Board of Orthodontics. They concluded that the change in the total alignment score in the Invisalign group was significantly larger than that for the Braces group. An MSc dissertation by Fetouh²⁷ concluded that Invisalign can treat mild cases as efficiently, if not better than fixed appliances. It is clear that there is a paucity of robust evidence regarding the effectiveness of aligners compared to fixed appliances and there is need for good quality clinical trials in this area.

CASE REPORTS ILLUSTRATING THE CONCEPT OF SHORT ORTHODONTIC TREATMENT

Patient A

This case describes an example of a non-digitally planned, simple anterior alignment with a 7.5 year follow up. The patient presented at the age of 21 having had previous orthodontic treatment with fixed appliances. She had been offered a further course of fixed appliance treatment but did not want to wear these. Her main complaint related to her lower teeth; she was unhappy with the increasing amount of crowding which was occurring and she was not wearing any retainers. All options were offered and she chose an Inman Aligner because she wanted something removable and she only wanted to deal with her lower anterior teeth. Space was available and a single arch treatment was feasible.

An arch evaluation was carried out using models and the Hanchers technique,²⁸ and a proposed curve setup. The 41 would be retracted a little and the in-standing incisors advanced. The goal would be to move the teeth to a position of best stability. Using the proposed curve a crowding figure of 2.8 mm was calculated and the case was deemed suitable for Inman Aligner treatment. An

impression was taken and submitted to the laboratory where a Kesling setup was created with the arch evaluation landmark teeth respected. The aligner was then constructed on that model so that when the patient returned the proposed position and occlusal contacts could be checked.

Space creation was focused around the canines and the flared areas of the incisor teeth – those areas that had not received much natural proximal wear. Inter-proximal reduction (IPR) and predictive proximal reduction (PPR) was carried out using strips and discs in a progressive manner with only 1.2 mm spread over the front seven contacts at the first appointment. Further IPR focused on the contact points between the canines and premolars to allow the canines to upright slightly. Progressive space creation ensured that more anatomical contacts were created and reduced the likelihood of excessive IPR. Composite anchors were placed to direct the forces driving out the in-standing teeth first. Anchors placed in sequence dramatically increases treatment times by allowing facial movements before retractive movements. Two more sessions of IPR were conducted every 2–3 weeks. At week 7 simultaneous bleaching was carried out and the teeth reached their final position after 9 weeks. A laboratory constructed a multi-strand stainless steel indirect fixed retainer which was placed a few weeks later. An Essix retainer was given to the patient to wear on top of the fixed retainer at night-time for three months. The patient continues to use this occasionally to check fit. This helps to prevent relapse in the event of a de-bond of the fixed retainer which has remained *in-situ* over 7 years. Case pre-treatment and follow-up photos (after 5 and 7 years) are shown in Figures 16–22.

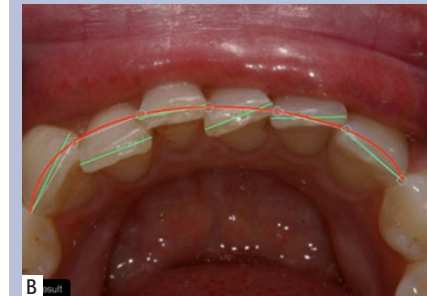
Patient B

This patient presented with primarily an aesthetic concern regarding her upper teeth. She was not happy with the edges of her upper teeth despite several previous failed attempts to restore them (Fig. 23). She was also considering veneers. The patient recalled that her lower teeth were once straight but over time they had become irregular, 41 had moved forwards and become darker with more exposed dentine.

If the patient’s upper teeth were restored with either composite or ceramic veneers with the current anterior contact arrangement, then initially this would be satisfactory but as the lower teeth continued to move over time, contacts would potentially worsen as the lower central incisors moved forwards, potentially causing the upper anterior composite to chip or causing the 21 to move anteriorly. It was explained to



Fig. 23 Lower anteriors before treatment showing wear and increasing crowding



Figs 24a-c (a) A occlusal before treatment; (b) spacewise trace 2.8 mm crowding; (c) after treatment

the patient that an underlying tooth position problem was responsible for the shape of her teeth. All orthodontic options were offered including a referral but the patient chose removable aligners to correct the problem before potential further restorative treatment (Fig. 24).

The plan was to improve the incisal contacts and to effectively place the teeth into the position they once were. This was achieved with clear aligners on the upper incisors and an Inman aligner on the lowers.

First, a landmark tooth or point was chosen. This is a position of relative stability where a tooth, or point of a tooth, has remained in a functional and an aesthetic position. In the upper arch the laterals were chosen and in the lower arch the midpoint of the 31 and this tooth would be rotated about its axis. Planning was executed by creating a digital SPACEWIZE™ (Fig. 24b) arch trace to



Fig. 25 Smile (a) before treatment; (b) after alignment/whitening, (c) after edge bonding



Fig. 26 (a) Close view before alignment and (b) after clear aligners, whitening and edge bonding

illustrate the landmark and show where the other teeth were to be placed. These traces enable the creation of an ideal arch based on the landmark points showing where the teeth will end up and allow the calculation of the amount of crowding according to Hancher’s technique. (This enables the arch evaluation to be done with the patient in the chair.) This trace instructed the technician to correctly set up the teeth according to this occlusal prescription using Ortho Analyser software. The Inman Aligner was



Fig. 27 Smile in occlusion after treatment



Fig. 28 Occlusal plan and landmark point

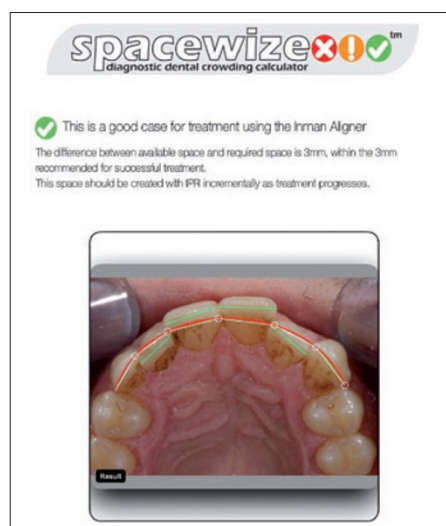


Fig. 30 Spacewize trace with proposed arch form

then constructed on the 3D models created by the printers. The Clear Aligners were constructed on the Kesling models.

Three upper Clear Aligners were constructed for the upper arch and an Inman Aligner was used in the lower arch. Measured, progressive IPR and PPR was carried out (0.3 mm on the upper incisors, 1.8 mm on the lower incisors) based on accurate 3D printed models. The alignment phase took 8 weeks before moving to the retention phase. Simultaneous tooth whitening was carried out in the last phases of treatment using bleaching trays made with a double seal to prevent loss of gel and saliva ingress. Almost immediately at this stage the patient could see her teeth were becoming straighter and whiter, she rejected the idea of veneers and elected to have composite bonding (Figs 25–27).

After alignment, the right amount of space had been created which allowed the placement of the upper composite bonds. These

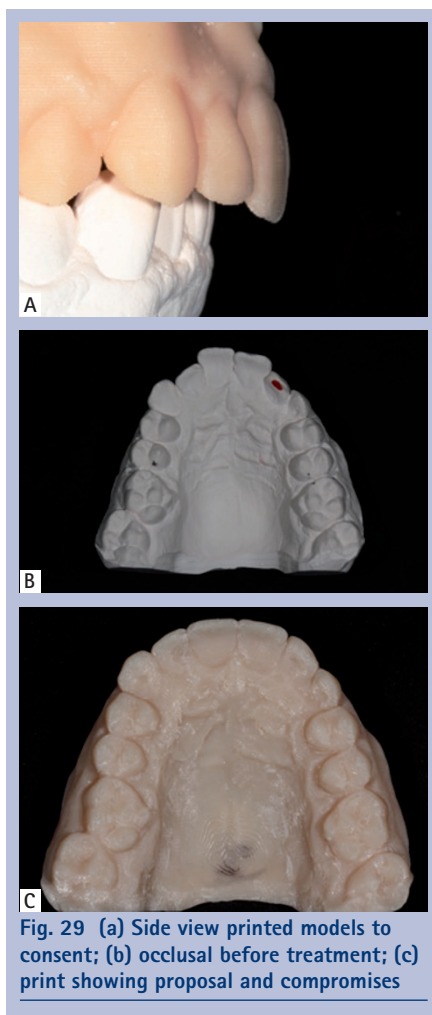


Fig. 29 (a) Side view printed models to consent; (b) occlusal before treatment; (c) print showing proposal and compromises

additions were placed (no preparation or bevel) on the four upper incisal edges. Slight composite ramps were placed on the palatal aspect of the canines to ensure guidance on excursions. The patient was instructed to wear Essix retainers on a full-time basis for several months and continues to wear these at night. There is an option of switching to a fixed retainer. The lower incisal edges may be treated eventually.

This process is progressive in that patients see their teeth change and are able to make judgements based on these changes. The alternative is that the tooth positions are designed with digital software which fails to show the changes possible with orthodontics, bleaching and bonding. The most common solution is to place veneers but this is not the preferred solution.

Patient C

This case will be used to demonstrate consent using 3D printing. The patient had been offered correction through porcelain veneers. This was a difficult malocclusion with a significant Skeletal II base. All options were discussed and the patient was informed that the Skeletal II base could not be changed with aesthetic orthodontics, and only the

overjet could be improved. The patient was not sure if this would be acceptable and a 3D model preview was used to illustrate a realistic outcome (Figs 28 and 29).

The first goal was to evaluate the aesthetics and function as well as to decide on a landmark tooth. As part of the digital planning process, the landmark teeth are not moved to ensure the proposed curve is not expanded or over constricted. Both upper central incisors were to be retracted by 3 mm and the upper lateral incisors were to be advanced by 1 mm. A photograph of the occlusal view was taken in the chair and uploaded to the digital software (Fig. 30). One tooth was calibrated and the curve then set according to the landmark tooth and the realistic tooth movements. The amount of crowding was calculated at 3 mm. The tooth chosen was an upper left deciduous canine (the permanent canine was missing). This tooth was in the correct position so became the landmark tooth and no orthodontic force would be applied to it.

Using Ortho Analyser software the laboratory moved the teeth to the position decided upon based on the landmark teeth. A model was then printed and returned to the practice to show the patient, who could then view the teeth that were and were not being treated.

The extent of the overjet reduction was evident and the patient was happy with the fact that it would not be complete without treating the lowers. He was also made aware of the 16 which was in cross bite and could not be treated with anterior alignment alone. It was also evident from the corrected model that the incisal edge outline would need bonding after alignment because of previous differential tooth wear and chipping. After fully understanding and visualising what the potential outcome would be and understanding how comprehensive treatment would improve on these outcomes, the patient decided to have the compromised treatment followed by bleaching and some edge bonding.

An Aligner was fitted and the IPR/PPR was carried out progressively over three visits. Whitening was started at week 9 using super sealed trays and with the patient bleaching for 35–45 minutes a day while the aligner was out of the mouth. Three weeks later a laboratory-constructed, multi-strand, stainless steel retainer wire was fitted²⁹ and composite edge bonding was placed on the 11, 21 and 22 and a composite veneer on the 23.

The tooth surface was roughened with a diamond bur then a retainer was fitted and the occlusion adjusted to ensure the patient had canine guidance on the right side and retained group function on the left to protect the deciduous canine.³⁰ A clear Essix retainer was provided to fit over the fixed retainer for the patient to wear at night initially. The end

result was achieved with his natural dentition rather than long term, high maintenance, ceramic porcelain veneers (Figs 31–34).

CONCLUSION

The concept of short orthodontic treatments is not new and there are many clinicians capable of producing high quality treatment results. The fundamentals of orthodontic assessment, treatment planning and case management are essential to avoid unwanted outcomes and unhappy patients. These skills are not easily acquired and require adequate training and continuing professional development. Appropriate training mentoring and supervision is advised for those wishing to develop these additional skills.

T. Qureshi is a Clinical Director of Inman Aligner. D. Roberts-Harry is a clinical trainer and lecturer for Invisalign and sits on the UK Advisory Board of Invisalign. Note: The case involving Patient B was first published in The Dentist Sept 2013; 60–62.

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Fig. 31 (a) Before treatment; (b) after alignment and daywhite; (c) after Venus Diamond Edge bonding



Fig. 32 Occlusal after treatment with no flaring and controlled curve

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Fig. 33 Full face at 6 month review



Fig. 34 (a) Before treatment; (b) 12 weeks later

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