

Rotating canines using the Invisalign system

Paul Humber provides us with a detailed analysis of this procedure

Background

Invisalign is an orthodontic system whereby we can design treatment plans on a computer using Align Technology's ClinCheck software, while simultaneously drawing on Invisalign's experience of treating approximately two million patients. A series of clear 'aligners' are then created for the patient to wear, which progressively straighten their teeth. At the end of the first set of aligners, the clinician will have the option to take new impressions or an intra-oral scan, which can be scanned back onto the software system so that new 'refinement' aligners can be created to fine tune the result if necessary. In the UK, over two thousand clinicians have so far been trained in the technique.

Since its inception in the late 1990s, Align Technology has constantly researched this area of orthodontics and developed its product, software and materials so that the technique has seen innumerable innovations and improvements; last year alone it spent \$37 million on research and development (Align 2012). As a result, interest has been high in the dental community to establish the strengths and limitations of this technique and discern its role when selecting the best treatment options for patients.

Research from recent years has shown a consensus that clinicians certainly feel very comfortable using the Invisalign system in Class 1 malocclusions with mild to moderate



Education aims and objectives

To gain an understanding of the background to the Invisalign orthodontic system and the practical aspects of its use when rotating canines into line.

Expected outcomes

The reader will learn how to carry out this procedure via the use of computer designed attachments through the ClinCheck software, and understand the best current approach for canine rotation.

imbrication. For example Fetouh (2009), in a study where they paired 67 cases treated by fixed appliances and Invisalign, stated that 'There was no statistical significant differences between the scores of the Invisalign group and Braces group for Alignment, Occlusal Relationship and Interproximal Contacts. The Invisalign group had better scores in Marginal ridges, Bucco-lingual inclination, Occlusal Contacts, and Overjet than Braces group.' They further concluded 'According to OGS, Invisalign can treat mild malocclusion with DI less than 5 as efficiently, if not better, as braces.' In this study refinement aligners were used as deemed necessary by the treating clinician, rather than restricting the findings to the result of the first set of aligners worn by the patient.

Other researchers, when investigating Invisalign, have employed a methodology whereby only one set of aligners was used to correct a malocclusion and their effects assessed, and these studies can sometimes tease out the areas of treatment where Invisalign may well prove to be successful but may need more than one set of aligners to achieve the treatment objectives. To judge the technique purely on such studies would be as illogical as judging fixed appliance work based on a study where only one arch wire was used and no adjustment of the wire or brackets was allowed, even if they got damaged or lost. Such studies are useful, however, to help an informed clinician understand the hurdles that a specific technique

may face, to weigh up the solutions to those problems, and to judge the use of Invisalign in more severe imbrications and when addressing Class 2 and Class 3 malocclusions.

Rotating canines into line

One area that is frequently explored in the literature is the issue of rotating canines into line. Kravitz et al (2008) assessed the rotation of 53 canines in 31 patients using the Invisalign system. They observed that the highest accuracy was achieved by the group of patients where the canines were kept separate from the adjacent teeth by using some minimal interproximal reduction during treatment, 'indicating that the presence of interproximal contact may be a critical factor in the success of canine rotation.' Nonetheless, even in the most successful group the initial rotation achieved was only an average of 43% of that proposed at the outset. The study was carried out in 2006 and they found at the time that the most common attachment used was a labially placed, centrally located, vertical-ellipsoid shaped attachment constructed from composite resin, and they felt that 'these attachments offered little clinical improvement over using no attachments at all.' Such attachments have since been superseded. Some authors prefer to analyse the rotation of teeth using regression analysis, for example Durrett (2004) at the University of Florida when she investigated the rotations of canines and premolars using different shapes of attachments.



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In her study she employed linear regression when rotating canines and premolars without any attachments to give the equation of Achieved Rotation = 1.06 + 0.26 (Attempted rotation), while the group of canines and premolars to be rotated with ellipsoid shaped buccally placed attachments showed an equation of Achieved Rotation = 0.31 + 0.37 (Attempted rotation).

A number of suggestions have been made over the years to aid the rotation of canines with Invisalign. Kuo et al (2007) suggested placing labial and lingual attachments on the same tooth, as has Boyd who also suggested that the clinician should factor some over-rotation into their initial plan, by adding 10% to the proposed rotation shown on the ClinCheck software (Boyd et al 2001 & 2007) so that, for example, if a rotation of 30 degrees is needed clinically, then a rotation of 33 degrees may be programmed into the ClinCheck treatment plan on the assumption that some of the requested rotation will not occur.

Meanwhile Align Technology has introduced and refined its computer designed attachments. Called 'Optimized Attachments', its software calibrates the exact amount and nature of movement required by the tooth, and assesses the shape of the clinical crown specific to each patient. It will then create a shape, size and position for the attachment that will be unique to that one tooth. The shape will incorporate an active surface that is not at the same inclination as the internal surface of the aligner. It therefore sets up forces between the aligner and the tooth which will encourage the rotation required. Align Technology then provides the clinician with an attachment template which can be used to construct an attachment in the mouth using composite resin. Features of these attachments include:

- They will usually be placed off-centre by the software, but the position is based on the exact shape of the tooth.
- The active surface of the attachment which engages the aligner is oriented such that a minimal extrusive force is delivered to the tooth ensuring no intrusion can occur.
- They are automatically placed by the software when a rotation of more than 5 degrees is detected in the plan.
- The need for a new template to allow a new attachment to be created should any attachment be lost or need replacing through poor fit. A specific development of these new attachments is that they are not necessarily the exact shape or in the same position as the female part of the aligner that fits over them and hence have activation.



Figure 1



Figure 2

Figure 1: Canine rotations of 45 to 55 degrees can at times benefit from additional techniques such as the use of detailing pliers.

Figures 2-5 show how Optimized Attachments look from different angles while **Figure 6** shows a patient with an aligner worn over her attachments on the lower arch. The attachments are designed with a number of different movements factored in and appear coloured red at the ClinCheck stage (**Figure 7**)



Figure 3



Figure 4



Figure 5



Figure 6

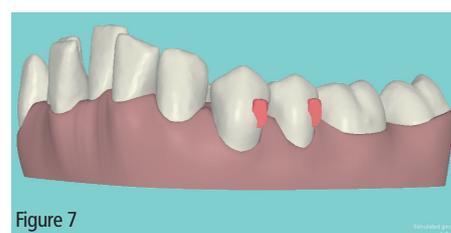


Figure 7

As a result, Align Technology states in its literature (Aligntech Institute 2012) that a canine rotation of up to 45 degrees should be found to be fairly reliable with their technique, while rotations of 45 to 55 degrees 'have shown good results with the use of aligners and at times, benefit from additional techniques' and that 'closer monitoring is recommended.' Such additional techniques may include buttons and

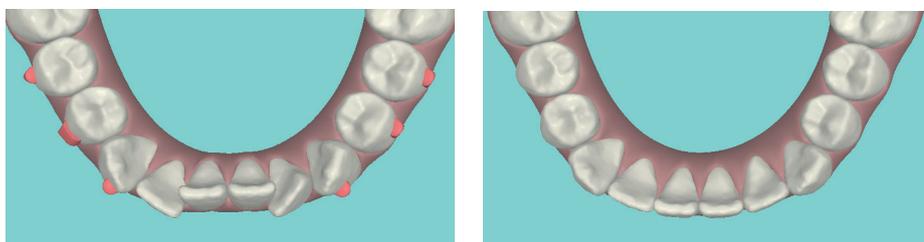
elastics or the use of detailing pliers (Figure 1). Figures 2-5 show Optimized Attachments and how they look visually from different angles, and Figure 6 shows a patient with an aligner worn over her attachments on the lower arch. The attachments are designed with a number of different movements factored in and appear coloured red at the ClinCheck stage (Figure 7). The attachments will ultimately be created in the mouth by the treating clinician using composite resin in the manner shown in Figures 13-21.

Aim of the study

The aim of this study is to assess the in vivo efficacy of one set of Invisalign aligners at



Figures 8-9: The attachments were monitored every six weeks by removing the aligner and marking the most labial point of the attachment with a pencil. The aligner was then replaced to see if the pencil mark shone through the aligner at the appropriate place



Figures 10-11: The same patient whose teeth were scanned into ClinCheck before, and after, one set of aligners



Figure 12: When rotating a canine, it is recommended that the tooth is checked mesially and distally throughout treatment with floss to ensure it is not binding interproximally. If necessary, the contact may be eased with some thin interproximal strip

rotating canine teeth amongst patients treated in private practice in a manner that can be compared to the previous similar research and that which will occur in the future, but using the new Optimized Attachments recommended by Align Technology.

Materials and methods

Consecutive patients were selected who met the following criteria:

- They had malocclusions that were to be treated with the Invisalign system of aligners alone.
- No fundamental change in the molar relationship was required as part of treatment.

- The treatment plan of each patient showed at least one canine that needed to rotate more than 5 degrees and less than 45 degrees.
- The new Optimized Attachments were used to rotate the canines.
- The patient was then available for a subsequent impression so that a second file was possible to assess the rotation achieved.

The attachments were monitored every six weeks, as far as proved possible, throughout active treatment to check their integrity and their fit within the aligner. To do so, the aligner was removed, the most labial point of the attachment was marked with a pencil, and

the aligner replaced to see if the pencil mark shone through the aligner at the appropriate place (Figures 8-9 show this technique applied to a lateral incisor). If there was any doubt at all, then the attachment was replaced as recommended by Align Technology using an attachment template. The canines were checked every six weeks to check that there was no binding interproximally. If floss could not be passed easily through the contact point then some 0.08mm interproximal reduction strip was passed between the teeth to ease the contact mesially and/or distally (see Figure 12). Impressions were taken at the end of treatment to be scanned into Align Technology's ClinCheck software. The amount of rotation achieved was then measured using two methods: the figure shown in the software of the rotation required as measured by the 'Tooth Movement Assessment' was noted and compared to the figure provided by the first file's Tooth Movement Assessment. Secondly the degree of rotation required was measured visually using fixed points in the arch such as second and third molars where no movement was planned for them. If there was a discrepancy between the two measurements, they were checked and, if necessary, an average of the two was taken.

No over-rotation was programmed into the treatment plans. Figures 10-11 show an example of a patient whose teeth were scanned into the software before, and after, one set of aligners.

Results

- Number of patients: 15
- Number of canines rotated: 33
- Mean rotation required: 20.7 degrees (range 7 to 42 degrees)
- Mean rotation still required after one set of aligners: 7.55 degrees (range 2 to 20 degrees)
- Mean percentage of rotation achieved: 63.6%
- Simple Linear Regression: Achieved Rotation (degrees) = 1.54 + 0.56 (Attempted rotation)
- Upper canines (n = 11) Mean rotation required 21.8 degrees. Mean rotation still required after one set of aligners 9.1 degrees. Mean percentage of rotation achieved: 58.3%
- Lower canines (n=22) Mean rotation required 19.7 degrees. Mean rotation still required after one set of aligners 6.8 degrees. Mean percentage of rotation achieved: 65.7%
- Number of teeth where the attachment was changed during treatment = 8. Uppers = 3
Lowers = 5.

Discussion

This relatively small study will be unable to throw up statistics that are profoundly robust



Figure 13



Figure 14



Figure 15



Figure 16



Figure 17



Figure 18



Figure 19



Figure 20



Figure 21

Figures 13-21: The attachments are created in the mouth by the treating clinician using composite resin

and therefore the over-analysis of the figures has been avoided, but the study should be large enough to be capable of spotting problems and should give us an overall sense of how much progress is being made by this popular technique as it is refined and developed.

During the study, the clinician felt that the clinically 25 of the 33 canines were tracking well when assessed visually. The eight where it was felt that tracking was poor, had their attachments replaced during treatment. This is in accordance with the recommended protocol of Align Technology, but shows that even studious attention to the progress of treatment does not in itself necessarily result in perfect canine rotation at the first attempt.

Inevitably, Invisalign aligners are removable and therefore are subject to patient compliance. The patients in the study were requested to remove the aligners for eating and oral hygiene but may be kept in place when drinking neutral drinks. The stated aim was to wear aligners for 22 hours a day on the assumption that this should result in patients wearing the aligners for the 20 to 22 hours a day recommended by Align Technology. Inevitably however, patients will vary in their level of compliance. This is a drawback compared to fixed appliance therapy, which by nature have to be worn full time, but the advantages of removable appliances include a greatly enhanced chance to keep oral hygiene to a good standard and this has in turn shown

that patients who wear aligners have better gingival health than those who have fixed appliances (Taylor et al 2003) and very low rates of enamel demineralisation (Humber 2008). Furthermore, the nature of Invisalign is such that the teeth are set by computer to move at a speed that will allow the periodontal ligament a maximum chance of maintaining the integrity of its blood supply (Tuncay 2007) and as a result studies are now showing that when Invisalign is used, no measurable root resorption is observed (Boyd 2007b).

Conclusions

Since its inception in 1997, the rotation of canines using the Invisalign technique has been thought to be potentially problematic,

but a review of the literature and the results of this study reveal progressive improvements in this area.

The following would appear to be the best current approach for canine rotations of between 5 degrees and 45 degrees:

- The use of the new Optimized Attachments as recommended by Align Technology when it appears in the ClinCheck set-up.
- Careful monitoring throughout treatment to ensure that the attachment and aligner fit each other.
- Replacement of an attachment if it is lost or if it needs to be replaced when deemed to be ill-fitting, using the recommended template from Align Technology.
- Monitoring throughout treatment to ensure that the canine is not binding interproximally, and easing the contact point if needed with interproximal reduction tape.
- The use of auxiliary techniques and/or refinement aligners if the desired rotation is not achieved with the first set of aligners.

Care to comment? @AesDenToday

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