

A snapshot of Invisalign

Paul Humber gives us a brief analysis of Invisalign cases and what they can achieve

Abstract

Forty Invisalign cases were examined that finished consecutively to assess current treatment time spans compared to previous Invisalign studies and alternative techniques. The Invisalign treatment protocols were altered significantly in 2007 and so the figures were analysed further to see what effect this may have had on treatment times. The average treatment time of the whole sample was 12 months, this compares to 10.25 months for the sample of 24 who commenced in 2007 and 13.5 months from a similar study of patients undertaken in 2003-2006. The statistical validity of these figures is discussed along with the potential mechanisms that may affect time spans with these techniques.

Introduction

When patients consider orthodontic treatment, one of the most likely questions they will ask is 'How long will it take?' and any answer that we give forms part of their informed consent. Furthermore there is a requirement for clinicians to give financial estimates at the beginning of treatment and these are determined to a large degree by the subsequent length of treatment. As a result, it is worth quantifying what we know about the typical time spans of the available techniques in order to give an informed response to our patients when they make enquiries about treatment.

Background

Invisalign is an orthodontic system where the patient's impressions are scanned using computerised tomography and presented on a computer using Align Technology's ClinCheck software. A treatment plan is then designed to the clinician's requirements while simultaneously drawing on

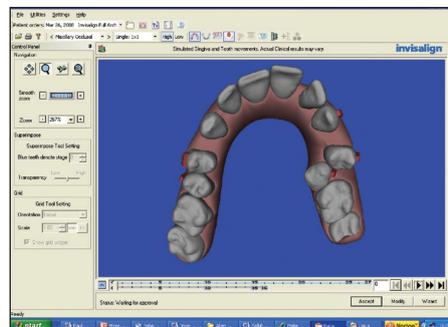


Figure 1a: the upper arch in an Invisalign case on the 'ClinCheck' software, pre-treatment. The red marks show where the computer recommended we add composite attachments to the teeth to aid their movements

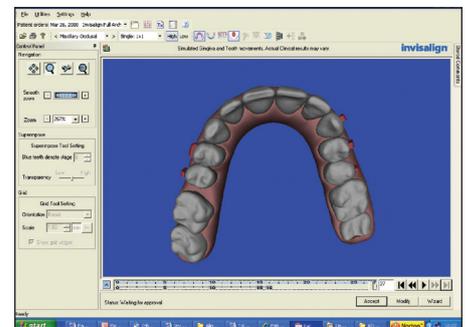
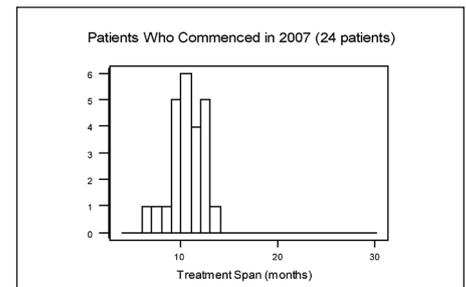
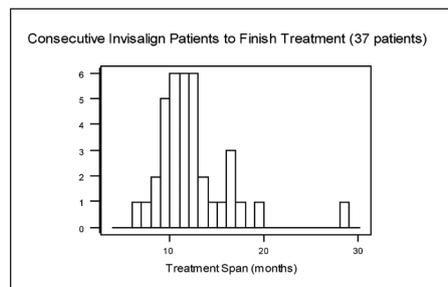


Figure 1b: The same arch on ClinCheck showing what the current plan will look like after 27 aligners



Invisalign's experience of over 500,000 previously completed cases. The ClinCheck software allows us to predict the likely treatment time of the first set of aligners, but clinicians routinely use a second set of aligners to 'fine tune' the occlusion and the time span of those is not known at the outset of the original plan.

Align Technology creates protocols for how, and at what speed, the computer moves the teeth during the course of each treatment. These protocols have been altered repeatedly since their inception in the late 1990s through a system that involves clinical trials, a full time research team, and a panel of working orthodontists and university lecturers (Align 2008). On January 1st 2007 an unusually large tranche of changes occurred and there were supplementary changes later in the same year (Sterental 2008 and Boyd 2007). The changes on 1st January 2007 can be summarised as follows:

1. Simultaneous movement are now planned for all involved teeth subject to sufficient anchorage.
2. Complex movements required by one tooth (i.e. rotation and root uprighting) are now performed at the same time. This usually ensures that the less predictable root movement is per-

formed at a reduced velocity since it is taking place along the greater number of stages required by the easier crown movement.

3. A change in the design of attachments occurred to allow greater control of teeth
4. The rate of certain types of tooth movements thought to be historically problematic was slowed. These movements are now routinely started earlier in the plan.
5. A space of approximately 0.1mm is now kept between teeth during movement of one tooth past another.

It is assumed that these measures will lead to shorter treatment times because there will be a more accurate result with the first set of aligners, and because under previous protocols, more problematic tooth movements were often placed at the end of the treatment which added time to the plan. This study represents probably the earliest opportunity that data mining can be carried out to see if the treatment times are indeed changing.

Materials and methods

This study examined 40 consecutive cases that were completed in the months up to April 2008.



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Figures 2a-e: The patient had been sucking her fingers well into her twenties and had insisted on avoiding fixed appliances. The case involved the use of composite attachments to help the aligners grip the teeth (2c) which are visually unobtrusive. Figures 2d and e are 20 months later

Treatment time spans were calculated from the first PVA impression required under Align Technology's protocol until the provision of retention, and were measured to an accuracy of the nearest half month. The cases were treated in Cambridgeshire exclusively using Invisalign by a clinician who has been using the technique since 2003.

The clinician's own treatment protocol was to treat the patient with one set of aligners which were worn full time except for eating and cleaning. If compliance was judged to be high and the teeth were tracking well, the aligners would be changed every ten days. After a first set of aligners, a second impression would usually be taken to return the case back to the ClinCheck software where the case could be fine tuned with a second smaller set of aligners.

The inclusion criteria of the cases to be treated was constant throughout the period that the cases were commenced. The results were analysed using the total group of 40 patients, and separately to examine the patients in this group who started their treatment after January 1st 2007.

Results

Three patients were excluded from the study where either full records were not available or the patient could not be contacted. This left 37 patients who were analysed (Group A), 24 of whom had commenced treatment after January 1st 2007 (Group B).

Group A (n =37)

The shortest treatment span was six months and the longest was 28 months. The mean treatment time was 12 months. The median value was 11.5

months. The mode value is given in histogram A as 11.5 months.

Group B (n=24)

The shortest treatment span was 6 months and the longest was 13.5 months. The mean treatment time was 10.25. The median value was 10 months. The mode value is given in histogram B as 10.5 months.

A note on statistics

The methodology for Group A is likely to be robust because it is drawn from a continuous stream of 343 patients dating back to 2003. Treatments that had taken an unusually long time, therefore, would stand a high chance of showing up in the sample in their correct proportion.

In Group B, who all commenced treatment during 2007, there is a zero probability that a treatment time over 16 months would appear in the sample, because the patient would not yet be finished. This would be expected to reduce the mean value and potentially mislead us. We would need to use statistical modeling therefore to assess how the mean may have been affected. In a true Normal Distribution, the mean, mode and median would share the same value and, for example, 68.2% of the value would fall within one standard deviation of the mean. In Group B, the mean, median and mode are within 0.5 of each other and 68.75% of the values lie within one standard deviation of the mean, implying that a normal distribution is a good model for these figures. The implication of this is that if the study had been carried out later in 2008 the mean for Group B would be nearer to 10.5 months, up from its current value of 10.25 months.

A comparison with other studies

The results of this study compare favourably to the treatment duration of the same clinician's first 100 consecutive cases which were treated in 2003-2006 (Humber 2008) where the mean time span was measured clinically at 13.5 months.

Looking at other research, these figures would appear to be broadly in line with data from practices in the USA. For example, Vincent (2005) analysed 65 Invisalign cases from seven practices and found that the average duration of treatment was 12.5 months.

To gauge whether treatment times are falling as the Invisalign technique is refined over the years we might look at studies from the earliest years of the technique. Djeu et al (2005) examined 48 Invisalign cases treated in 1999-2002 and showed a mean treatment time of 16.8 months. Before that Vlaskalic reported in 2002 that for a class I occlusion with mild crowding or spacing, the mean treatment time was 20 months, while at the other extreme, class I and class II division 2 occlusions with severe crowding and class II division 2 cases with moderate crowding were taking an average of 32 months. The total sample in that study was 38 patients, and the technique employed in that era involved a series of impressions and the use of multiple sets of aligners so it may have had more in common with other current aligner techniques than with modern day Invisalign.

Comparing Invisalign to other techniques

How do Invisalign treatment times compare to



Figures 3a-d: This patient presented seven weeks before her wedding hoping for straighter teeth. We set the computerised treatment plan to resolve the upper incisor rotations before her wedding, and to address the buccal occlusion thereafter

Figures 3c and d: The same case seven weeks later

What potential mechanisms could make Invisalign faster?

It is unlikely that plastic in itself somehow acts more or less rapidly than metal archwires. Clinical experiments have shown that the rate of tooth movement is not consistently greater with light or heavy forces, even when applied to opposite sides of the same mouth (Andreasen et al 1980). So provided that forces for both fixed appliances and aligners are kept within reasonable parameters we may expect them to yield similar time spans in vivo.

It is likely, however, that a list of factors influencing the speed of treatment would include some or all of the following:

- Poor treatment planning
- Anchorage loss, leading to setbacks
- Too much anchorage, so that few teeth are moving at any given time
- Teeth impeding each other's progress during treatment
- Poor execution of treatment plans, for example by placing the pressure on a tooth at an incorrect angle or with an inappropriate force.
- A change in treatment goals.

As we survey this list it becomes apparent that every one of these factors would be improved by a computer-based treatment planning system. For example, the ClinCheck software is set to make the most of reciprocal anchorage and because the computer will always help both the clinician and patient to envisage the final result, there is a reduced chance of wanting to change the treatment goals as the result becomes apparent.

Treating ever more complicated cases

Is it the case that we are simply treating patients with simpler occlusions? If that were true then the shorter treatment times would be no surprise. It is difficult to quantify over the industry as a whole, but the cases in this study are quite

wide in scope (Figures 2-4) and not demonstrably different from the clinician's earlier years (Humber 2006, 2008).

When new clinicians are learning to use Invisalign they are encouraged to start with simple cases, for example Class 1 occlusions where rotations are less than 30 degrees and intrusions are less than 2mm (Align 2008). This is hardly surprising. You wouldn't teach a child to swim and then enter them in for the Olympics the next day. This has led to a misunderstanding that only simple cases can be treated with Invisalign. Even a cursory scan of journals reveals a wealth of more complicated work as the years pass (Miller et al 2002, Womack 2006, Boyd 2007). Invisalign is also now being routinely used in conjunction with auxiliaries such as interarch elastics (Perelmuter 2007).

Clinical and patient advantages

An Invisalign treatment plan will always be set by the computer to make teeth move as reasonable increments of the width of the periodontal ligament (Tuncay 2007). This means the ligament's blood supply has the highest chance of maintaining its integrity while maintaining enough force to move the teeth.

This has been shown to result in more comfort compared to fixed appliances (Miller 2007). It has also been suggested that such a strategy would reduce the chance of resorption (Tuncay 2007, Segal et al 2004) and Professor Boyd recently pointed to the fact that this is now being shown to be the case in practice. In a recent longitudinal study of 100 consecutive Invisalign cases no measurable root resorption was found, while an average 10% of patients treated with fixed appliances have clinically significant root resorption of at least 3mm (Boyd 2007).

Because aligners can be removed for eating, drinking and cleaning, they have resulted in better gingival health (Taylor et al 2003) compared to fixed appliances. In terms of demineralisa-

fixed appliances? The Djeu et al study (2005) mentioned above analyzed 96 cases of similar complexity, half of which were treated with Invisalign and half with tip-edge fixed appliances. The conclusion was that 'Invisalign patients finished four months sooner.' 'There was a statistically significant difference between the treatment durations of the groups: 1.4 years for the Invisalign patients and 1.7 years for the braces patients.'

How do Invisalign time spans compare to 'aligner' techniques that are not based on computerised planning?

The Inman appliance is designed to largely treat incisors leaving the intercanine width broadly constant. This is similar to the first seven weeks of the Invisalign case shown in Figure 3. Treatment times of 4-16 weeks have been reported (Qureshi 2008) but there is little in the way of quantified research. Clearstep is an alternative aligner technique where a series of aligners are constructed by taking periodic impressions of the patient.

Again there is little quantified research available, however the chair of the British Orthodontic Society Iain Hathorn (2008) in an article that specifically addresses Inman and Clearstep concluded these 'Aligner treatments usually take longer than conventional braces to achieve the same tooth movement...' This would seem logical in that if a succession of impressions throughout the treatment are needed then there will also be a succession of delays for new aligners to arrive. It is likely it would take longer than Invisalign, therefore, where the plan is usually carried out with one to two sets of aligners that are designed by computer, not by hand.



Figures 4a-e: This patient had been treated elsewhere with veneers to 'address' his anterior crossbite. The patient wasn't happy with the results which were unsightly and kept breaking. We set ClinCheck to design a plan based initially on the lingual surfaces of the upper arch, moving them over the bite
Figures 4c-e: Sixteen months later after the removal of the porcelain veneers

tion, one study with Invisalign showed that 5% of patients showed evidence of decalcification (Vlaskalic 2002), while a separate study of 100 consecutively Invisalign cases in the UK showed no additional demineralisation in the dentition of the patients treated (Humber 2008). Labially placed fixed appliances have been shown to cause demineralisation in 50% of patients (Gorelick et al 1982).

Add to this the clear audit trails, meticulous treatment planning and enhanced informed consent that ClinCheck allows, and this all represents a welcome reduction in the iatrogenic effects of traditional orthodontics.

Conclusions

Progressive refinements to the Invisalign technique would appear to be reducing average treatment times. A group of 37 patients whose Invisalign treatment finished in late 2007-early 2008 showed a mean treatment time of 12 months compared to 13.5 months for patients treated in 2003-2006. The statistics were further analyzed to look for early signs as to whether the 2007 Invisalign protocols were affecting treatment times and a further drop was detected in a small sample of 24 patients. These treatment times compare very favourably to alternative techniques, some of which have been shown to have severe iatrogenic consequences.

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