Evaluating clear aligners: part 1

In the first of a three part series, **Raya Karaganeva** gives a retrospective evaluation of clear aligners using the peer assessment rate index

The aim of this study was to retrospectively evaluate the role of clear aligners in adult orthodontics and to demonstrate the efficiency of Smilelign product. PAR scoring for randomly selected patients was conducted and the measurements were analysed. A dental laboratory audit was used to suggest the most common interventions. Also, a comparison between other products' outcomes and this study was included. Following the PAR index method, 30 cases were assessed using a PAR ruler. The cases were categorised into simple group (T1, n=23) with pre- treatment score less than 29 and complex group (T2, n=7) with score more than 30. The whole sample (T3) was represented on a nomogram. The reduction between start and finish treatment scores and the percentage improvement were calculated.

Analyses of the mean ± SD values for the variables were used to categorise sample improvement. Additional information such as treatment length, gender, jaw classification and IPR was noted. An audit looked at the frequency and type of refinements required.

T3 had average initial score of 23 PAR points which dropped to 6. Majority of the cases (n=21) were classified as 'Improved'. 60 % of T3 achieved 0-5 post-treatment PAR score and were considered to have ideal occlusion. Anterior segments had the highest improvement whereas no significant reduction was noted in the buccal occlusal component. The average treatment of T1 was 6 ± 1.95 months and it did not differ greatly from T2 (8 ± 1.98). 36% (n=71) of 200 sample were returned to the laboratory and required mid-treatment adjustments or extra aligners. These results demonstrate a relatively high treatment standard. For the purposes of establishing the clinical potential of Smilelign a continuous research should be carried out. More studies that look at tooth alignment several years after treatment should be published.

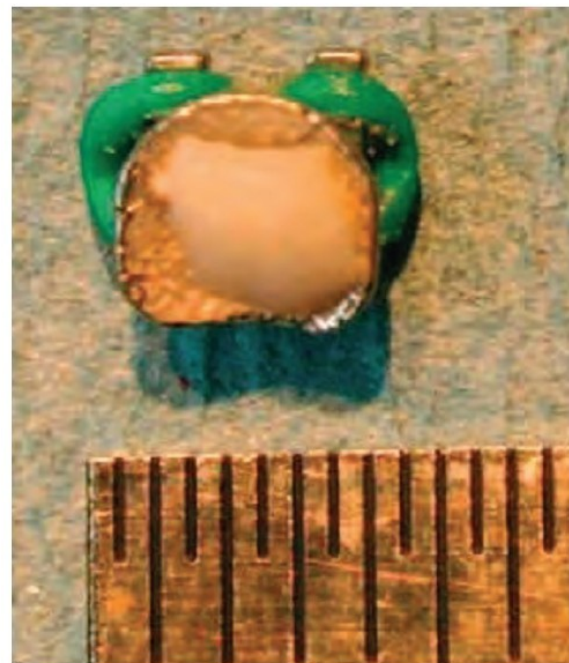Figure 1: Lingual braces (Shashwath et al., 2013:134)

Figure 2: Enamel fracture on debond (Travess et al., 2004:32)

Figure 3: Inman aligner(Inman Aligner, 2012)

Figure 4: Clear aligners (Smilelign, 2014)

Evolution in orthodontics

Over the last few centuries, the goals of orthodontic treatment planning have changed (Bosio and Liu, 2010). Norman Kingsley introduced the aesthetic importance of the treatment during the second half of the 19th century. Just a few years later, Edward Angle emphasised the occlusion as the preliminary objective and then in the 1980s again aesthetic results became critical for patient's satisfaction due to the introduction of some new materials (Sarvera and Ackermanb, 2000). 1900 marked the beginning of the so-called contemporary orthodontics. Many attempts for the correction of teeth alignment have been recorded – from primitive metal bands to lingual bonded ceramic braces, clear aligners, mini-implants, etc. Nowadays, the digital era provides a wide range of improved materials and methods for quality treatment (Bosio and Liu, 2010).

The demand for perfectly straight teeth has significantly increased and hence the market has become more competitive. Recently, varieties of different cutting appliances with improved aesthetics and function have been produced to attract both clinicians and patients (Walton et al., 2010).

Long-term fixed appliances

Metal brackets appliances are probably the most frequently recommended treatment, especially for teenagers (Park and Kim, 2009). Significant improvements in tooth alignment are present; particularly for people with severe malocclusions (BOS,

2008). To promote the treatment, different bracket shapes or ranges of colourful elastic ties have become part of fixed appliances (Walton et al., 2010). Buccal brackets have been replaced by less visible:
• Ceramic braces
• Lingual braces

Fixed orthodontics (Fig. 1) features rotating teeth and moving them bodily. Therefore, the treatment outcome is much better than after having removable appliances (Roberts-Harry and Sandy, 2004a). However, not only is the cost higher for both ceramic and lingual braces but some problems with bonding (Fig. 2) (Walton et al., 2010) and irritating the soft tissues have been reported (Park and Kim, 2009).

Short-term removable appliances

A study concluded that a small proportion of adults in the US have not chosen to undergo orthodontic treatment due to psychosocial limitations, aesthetic concerns and discomfort (Womack et al., 2002). Short-term orthodontics (STO) is predominantly a cosmetic treatment that can be applied even by general dentists. Nowadays, STO increases popularity as people are well aware of the existing advanced techniques. In addition, its benefits are highly promoted by the social media (Maini, 2013). Recent removable appliances are:
• Inman aligner
• Clear aligners

According to Maini (2013:83), Inman aligner (Fig. 3) is 'a NiTi coil activated appliance with clear anterior bars that compress the incisor teeth into alignment.'

However, it must be worn as much as possible to be effective (Grist, 2010).

Clear aligner concept

Kesling introduced the principles of the sequent clear aligners in 1945. However, in 1997 two graduate students- Zia Chishti and Kelsey Wirth, combined those principles with 3D technology and created the Align system to correct mild to moderate malocclusions (Shashwath et al., 2013).

The aligners are clear plastic moulds that resemble mouthguards but fit very precisely over the dentition (Fig. 4). Each aligner is being worn for two to three weeks and might be removed only whilst the patient is eating or brushing their teeth (22 hours per day). Teeth are moved slightly at each stage until the predicted outcome has been achieved (BOS, 2012; Seckman, 2015; Kuo and Miller, 2003). It is commonly accepted that Class I is the ideal jaw relationship (Fig. 5). However, 40% of the patients undergoing orthodontic treatment have Class II or Class III malocclusions. Some clear aligner products allow for treating of more complex malocclusions (Author unknown, 2011) by incorporation of different attachments and elastics (Simon et al., 2013).

In 1999, Invisalign were the first on the market to offer virtual treatment planning of this new treatment option (Graber et al., 2012; Meier et al., 2003). Following Invisalign, similar products such as: ClearSmile, Ormco, OrthoClear were established (Shashwath et al., 2013).

	Easy Case (mm)	Moderate Case (mm)	Not Recommended (mm)
Crowding	0-3	3-6	+6
Spacing	0-3	3-6	+6
Overjet	0-2	2-4	+4
Overbite	0-1	1-3	+3
Openbite	0-0.5	1	+1
Midline discrepancy	2-4	2-4	+4

Table 1.1: Guidelines for aligner treatment (Smilelign, 2014).

	DHC	AC
	1 and 2 No need	1 to 4 No need
Grades	3 Moderate need	5, 6 and 7 Moderate need
	4 and 5 Great need	8, 9 and 10 Great need

Table 1.2: Validation of Dental Health Component and Aesthetic Component need for treatment (Richmond, 2005: 24).

Components	
Upper and Lower Anterior Segments	Contact points (Fig. 1.9), Crowding, Spacing, Impacted teeth
Right and Left Buccal Segments	Position of teeth in Antero-posterior, Vertical and Transverse dimensions
Overjet	Increased overjet, Anterior crossbite, Negative overjet (Class III)
Overbite/ Openbite	Related to coverage of lower incisor by upper incisor
Centre Line	Discrepancy in relation to lower midline

Table 1.3.: PAR index components (Richmond et al, 1992a).

Reasons for popularity

Clear aligners' treatment is suitable for patients with permanent dentition (Vlaskalic and Boyd, 2002). The majority of them ask for a quick cosmetic treatment that can improve their overall facial appearance (Park and Kim, 2009; Meier et al., 2003). Even though, adolescents account for the biggest number of orthodontic cases, the number of adults has increased significantly in the last 10 years due to the aligners' high aesthetics and short period of adaptation (Warshawsky, 2014; Rossini et al., 2014; Mampieri and Giancotti, 2013). They are comfortable and easy to maintain (Grist, 2010; Shashwath et al., 2013). As the aligners are removable, good oral hygiene can be maintained and hence the negative effects on the periodontal tissue

are minimal (Rossini et al., 2014). Thus, many people are ready to choose aligner treatment despite its high price. Nevertheless, clinicians should embrace new products with caution in order to protect the patients (Vlaskalic and Boyd, 2002).

Incorporation of digital technology

Unlike most removable devices, which are constructed on plaster models, aligners are produced over stereolithographic models that are digitally manufactured by scanning the cast impressions (Kuo and Miller, 2003). Varieties of 3D computer software are available for the different clear aligners systems and they all allow manipulation of tooth position in all directions and prediction of tooth alignment after treatment (Vlaskalic and Boyd, 2002). A digital treatment plan defines how many aligners are required for a maximum improvement (Kuo and Miller, 2003). If any modifications are necessary, they can be adjusted at any point during the treatment (Park and Kim, 2009; Meier et al., 2003). The advanced technology reduces turnaround time and minimises chances of distortion and errors. Also, in case an aligner is broken or lost, a replacement can be produced quite quickly (Kuo and Miller, 2003).

Case selection

Treatment with clear aligners is found to achieve high success rates only if the case selection is correct (Warshawsky, 2014). It is useful to have an understanding of the treatment benefits and limitations (Kuo and Miller, 2003). Djeu et al. (2005) advised that the treatment is not suitable for patients with complex malocclusions, with severe irregularities and premolar extraction cases. However, adults who have mild to moderate irregularity could be selected for this system (Vlaskalic and Boyd, 2002). There are some recommendations for case selection (Table 1.1), but generally they are suitable for closing diastema (Fig. 1.6) (Park and Kim, 2009). Studies should be followed by clinicians as it might help them with the choice of appliance (Djeu et al., 2005; Kravitz et al., 2009).

In order to overcome crowding and avoid tooth extraction, interproximal reduction (IPR) creates some space for teeth to move into (Grist, 2010). The maximum IPR of the enamel is up to 0.25mm per tooth (mesial and distal), without interfering with tooth health (Mitchell, 2013).

Tooth movement with clear aligners

To increase the efficiency of the aligners, biomechanics and control of tooth movement should be taken into account (Arnett and McLaughlin, 2004). Nonetheless, there are just few science-based publications explaining tooth movement after treatment with the clear aligners (Drake et al., 2012; Kravitz et al., 2009). Treatment complexity governs the number of aligners in a
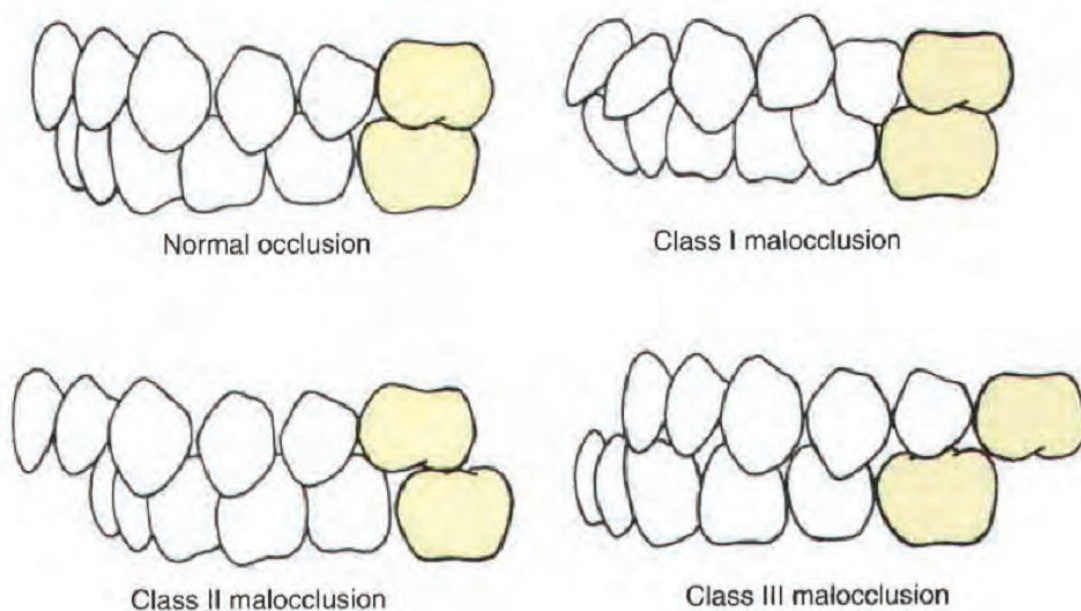

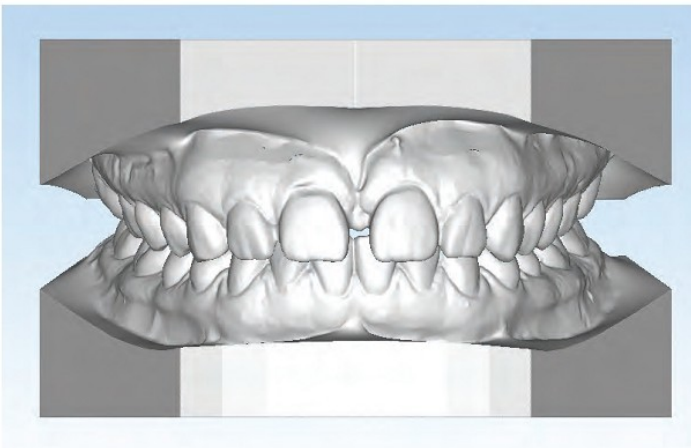Figure 5: Angle's classification of occlusion relationship (Biyani, 2013)

Figure 6: Closing diastema with Smilelign clear aligners treatment. It is a typical simple case
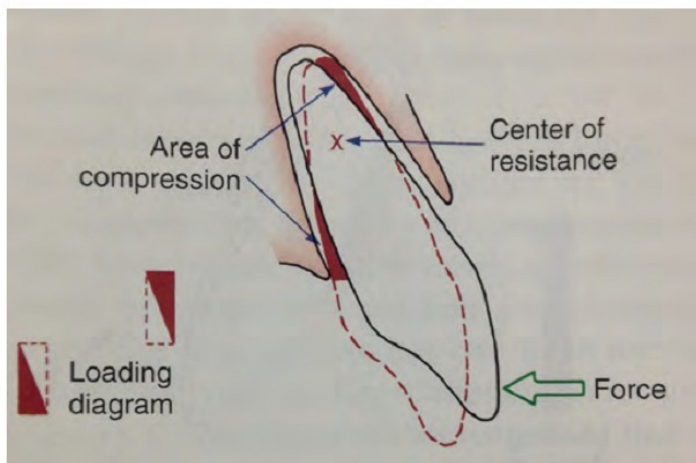

Figure 7: Force applied to the crown of the tooth to create rotation around the centre of resistance. Pressure is applied at the apex and crest of alveolar bone (Proffit et al., 2007:339).

treatment. Tooth movement achieved by one aligner is approximately 0.3mm (Warshawsky, 2014; Kravitz, 2009). The possibilities for slowing down the treatment might be due to uncontrolled movement and loss of anchorage (Drake et al., 2012).

Orthodontic movement of aligner treatment

The most commonly applied theory of bone remodelling is related to bone resorption taking place under pressure and bone formation under tension (Roberts-Harry and Sandy, 2004b). Graber et al. (2012) claimed that bone remodelling is encouraged more when pressure comes from intermittent forces for short period of time, which is typical for removable appliances. Tipping movement is predominantly achieved with aligners (Drake et al., 2012; Proffit et

al., 2007). The rotation centre is located between the root apex and centre of resistance (Fig. 7). Root apex is almost impossible to be moved by aligners and this is a significant disadvantage of the treatment as it limits the case selection (Park and Kim, 2009). However, a force of 18g could be enough to achieve body movement and the initial aligner force is around 200g. Therefore, aligners should be able to produce the desired movements, getting retention from the natural undercuts present (Graber et al., 2012).

Relapse

Patients' compliance is critically important for the removable appliances to be successful and this might have an impact over the treatment outcome (Djeu et al., 2005; Chate, 2013). If the patient does not wear the aligner for the optimum recommended time of twenty-two hours, the effectiveness of the aligners will decrease. To prevent any relapse of the dentition after treatment, it is recommended that the last aligner should be worn as a retainer overnight (Park and Kim, 2009). Post-retention might be recommended for a period of two to five years or in some cases a minimum of ten years (Grist, 2010). As STO is mainly tipping movements, retention after treatment is even more important (Maini, 2013).

The most common types of retainers are:
• Removable Essix retainer
• Fixed retainer (Fig. 8) (Grist, 2010).

Index of Orthodontic Treatment Need (IOTN)

Orthodontic treatment standards in many countries can be compared by using occlusal indices such as IOTN and Peer Assessment Rating (PAR) (Richmond, 2005). IOTN is used by orthodontists to determine the severity of patient's malocclusion and whether they will benefit from orthodontic treatment. It has aesthetic (AC) and dental health component (DHC) (Atkins, 2002).

- DHC reduces subjective measurements in regards with malocclusion disfigurement and oral tissue structures. It is based on five grades defining the need of treatment (Table 1.2). A ruler is used by clinicians to record the deviations (Brook and Shaw, 1989).
- AC consists of ten photographs representing different levels of attractiveness.
- It is rated from one, being the most attractive to ten-least attractive (Evans and Shaw, 1987).

It has been suggested that National Health Services in the UK would treat patients with DHC of three and above (Atkins, 2002). Approximately 35-40% of the cases have irregularities that do not raise any concerns in the patients (Birkeland et al., 1997).

Peer Assessment Rating (PAR) Index

The PAR index might be used in combination with IOTN to measure the occlusal changes and outcome after orthodontic treatment (Birkeland et al., 1997). It was created in the UK by 74 assessors after examining 128 dental casts. It is also used in over fifty countries for outcome evaluation or research purposes (Richmond, 2005). Richmond et al. (1992a) established the PAR scoring system that is valid and reliable criterion for severity and adequacy of treatment outcome. Approximately 75% of the UK orthodontists use occlusal indices to judge which patient is eligible for funded treatment (Le, 2006). The deviation from ideal occlusion can be determined by measuring PAR index components in Table 1.3.

The primary method of measuring PAR score is by using a PAR ruler, which has all information necessary to record the PAR components discrepancy. Individual measurements are taken from the pre- and post- treatment casts (Richmond et al.,1992a; Mayers et al.,2005).

Unweighted and weighted scores for each component are recorded on a PAR score sheet and they are used to calculate the overall improvement (Willems et al., 2001). According to British orthodontic opinion validation the overjet, overbite and central line components have more weighting to the end result, so their discrepancy can be appropriately emphasised (DeGuzman et al., 1995; Richmond 1992b). However, the weightings may differ in different countries (Richmond, 2005). Digital PAR score method is also available. Currently, COMP and ORTHODEX are the leading commercial software programmes that allow PAR index comparison (BOS, 2009). PAR scores of digital and plaster models are similar and hence both reliable measuring methods. The computer programmes allow assessors to manipulate the models and apply measurements (Fleming et al., 2011; Mayers et al.,2005). PAR index is useful for clinicians to assess their treatment standards (Deguchi et al., 2005). Under New Contract, April 2006, it is a compulsory for Primary Care Trusts and Local Health Boards to monitor minimum 20 cases plus 10% of the patients above 20 years of age (BOS, 2009).

Objectives

The aim of this study was to retrospectively evaluate the role of clear aligners in adult orthodontics and to demonstrate the efficiency of a particular product Smilelign. In order to do that, PAR scoring for randomly selected patients was conducted and the measurements were analysed. The improvement rate of Smilelign appliance for this sample was evaluated. A dental laboratory audit was used to suggest the most common interventions and the treatment outcome after adjustments. Also, a comparison between other products' outcomes and this study was included.