CLINICAL SECTION

Localized sequential use of resilient lining to generate orthodontic force in thermoformed active removable appliances

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A new modality of orthodontic treatment based on the thermoformed appliance was developed and trialled clinically. A light-cured resilient lining material commonly used for denture relining was placed locally and sequentially in thermoformed appliances to generate orthodontic forces. The new method appeared to be effective. All the presented cases showed substantial improvement in dental alignment. A number of orthodontic movements were demonstrated. Localized use of resilient lining in thermoformed orthodontic appliances appeared to be a promising alternative to other thermoformed active removable appliance (TARA) treatments. Further studies are required to optimize the procedures and explore its full potential.

Key words: Localized, resilient, aligners, thermoformed, active removable appliances

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Introduction

With the advent of Invisalign® (Aligner Technology, Inc., Sunnyvale, USA), it has become increasingly widespread to treat malocclusions with thermoformed active removable appliances (referred to in this study as TARAs). One dental school is teaching Invisalign® treatment to undergraduates.[1] The main advantages of this treatment are:

- the appliance is more aesthetic (a prerequisite for many adult patients);
- it is more comfortable, as no bulky brackets or wires are used;
- oral hygiene is easier to maintain and there are reduced eating restrictions.[2]
- this type of appliance is suitable for patients who are allergic to nickel.[3]

It can be assumed that the appliance is easier to work with. It does not require any special intra-oral skills. One of the main disadvantages is the cost. It can be deduced that the high cost may be related to the large number of TARAs required in each case and, more importantly, to the royalty payable to the manufacturer. In this article, a new method is described and cases presented using TARAs fabricated without the use of computers. The aim of developing this method is to attempt to provide a more affordable alternative and further enhance the popularity of TARAs.

There have been several methods advocated in generating orthodontic force in TARAs. The Hilliard Tooth-moving Thermopliers (Raintree Essix Inc., Metairie, USA) uses heat to create localized deformations. Minor tooth movements have been achieved. Invisalign® uses computer-aided fabrication. A common feature of these methods is that orthodontic force is generated by recovery of the wall of the TARA from its deflected position. TARAs fabricated with soft blanks tend to be less effective.[4] Using thicker blanks presents a different clinical problem in that the TARAs cannot then be fully seated unless the increments of change are very small. This is particularly evident when the point of applying the force is near the incisal edge or occlusal surface. Invisalign® overcomes this problem by issuing to the patient a series of many TARAs fabricated from a single impression using computer technology. Without the aid of computer, it would be impossible to fabricate so many TARAs at small incremental changes with such accuracy.[5]

Ideally, the orthodontic force should be sustained through distance and time, of a suitable magnitude and

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delivered at a point most suited to induce tooth movement in the desired direction.

A closer approximation to the ideal situation may be created by attaching a small amount of resilient material strategically in the TARA to generate orthodontic force. The material is compressed at insertion. It pushes the tooth along as it reverts to its original shape, along with recovery of the deflected wall. This allows sustained forces to be delivered over a longer distance and time. Furthermore, thicker and stiffer blanks can be used for thermoforming. Not only are the resultant TARAs more durable, they are also more retentive and afford better control of the anchor teeth. Such a material should be:

- resilient;
- of a suitable stiffness and when compressed generate forces within the physiological range for orthodontic purposes;
- bondable to the wall of the TARA;
- translucent or tooth-coloured;
- non-toxic;
- easy to add to and trim and allow easy chair-side processing.

All of the above properties are present in Triad Resiline (Dentsply International Inc., York, USA). This is a urethane dimethacrylate-based material, designed as a light-cured denture soft-liner and it stays resilient for up to a year. It is bondable to acrylic material such as Raintree Essix A+ plastic (Raintree Essix, Metairie, USA).

Procedure

Impression

The impression is obtained with a high quality alginate material, e.g. Cavex (Cavex Holland bv., Haarlem, Holland). The impression is sprayed with neutral detergent to lower surface tension and cast in high quality gypsum. This combination is generally sufficiently accurate and relatively inexpensive.

Model preparation

The model is trimmed to a size suitable for subsequent thermoforming. This step must be executed with care. Even minor damage to the cusp tips would greatly affect the fit of the TARA. The trimmed model is examined under magnification for defects. Comparison with the original study model is beneficial. Voids are filled with Triad Gel (Dentsply International Inc., York, USA). Spacers are placed on the model to create room for movement of the target tooth. Triad Denture Base Material (Dentsply International Inc., York, USA) is good for this purpose. It is translucent and allows easy gauging of the thickness of the applied layer. A small amount of Triad Gel is placed at the target tooth on the model to act as an adhesive. A small disc of Triad Denture Base Material is added, and manipulated by a small wax knife into the desired thickness and shape. The spacers are hardened by placing the model into a light-curing box, but if this is unavailable, a composite curing lamp can be used. In Figure 1, pieces of Triad Denture Base Material were placed on the distal aspects of UR3, UR4, UL4 and UL5 to provide room for distal movement of these teeth. The model was a working model of case 3.

Figure 1 A working model with spacers in place

Thermoforming

The material of choice is 0.040-inch Essix A+ plastic. It provides an accurate, retentive fit, good rigidity and bonds firmly to the resilient lining. Thermoforming is carried out by heating the plastic blank until it is soft and pulling it over the prepared model with suction force created by a vacuum pump. This procedure is similar to that in fabricating a mouthguard. The TARA is allowed to cool to room temperature on the model. It is then cut away from the model by using a wheel saw. The cured spacers do not adhere to the TARA and remain on the model. The TARA is trimmed to the gingival margin.

Insertion

Retention and accuracy of fit are checked. Shortening of the walls reduces the retention, particularly in the embrasures. Too much retention makes it hard to remove the TARA; too little results in instability when the TARA is activated. The occlusion is checked and adjusted to achieve even contact in maximal intercuspation.

Figure 2 (a) Case 1, before treatment. (b) Case 1, closure of central diastema. (c) Case 1, composite added to the lateral incisors

Activation

The area where the resilient lining is to be attached is degreased, a thin layer of Triad VLC Bonding Agent (Dentsply International Inc., York, USA) is applied and light-cured for 2 minutes. This is an important step because Triad Resiline does not adhere directly to Essix A+ plastic. A suitable amount of Triad Resiline is placed at the target area and light-cured. This is a critical step. The position and amount of material greatly affects the outcome of the tooth movement. More detail is provided in the case reports. After the initial cure, Triad Air Barrier Coating (Dentsply International Inc., York, USA) is painted over the resilient lining and returned to the light-curing box for completion of curing. The last step prevents subsequent discolouration of the uncured air-inhibited layer on the surface of the resilient lining. Excess Triad Resiline is trimmed off using a cross-cut tungsten carbide acrylic bur until the TARA can be seated fully with moderately firm finger pressure. The patient should feel pressure, but no pain. Simultaneous activation of a number of teeth is possible.

Progression

The patient is instructed to wear the TARA all the time except for eating, drinking and performing oral hygiene. After 7–14 days the patient is recalled and more resilient lining can be added by the same procedure. A new TARA is fabricated every 2–4 weeks requiring a new impression. Sometimes tooth morphology may not be conducive to force application in a certain direction. In this situation, small pieces of composite filling material are temporarily attached to the tooth to create more favourable engagement areas.

Case reports

Case 1

A Caucasian female, aged 58 years wished to have the central diastema closed without intruding or reclining the incisors. Overbite and overjet were acceptable to the patient. The maxillary central incisors were normal in size and the laterals were relatively small (Figure 2a).

Treatment. UR1 and UL1 were moved mesially (Figure 2b), and UR2 and UL2 were built up with composite (Figure 2c). In this case, tipping was discouraged by using the incisal edges as guides against the straight inner walls of the TARAs. Very small pieces of resilient lining were attached successively to engage the distal surfaces of UR1 and UL1 in order to push the teeth mesially together. Each increment was approximately 1 mm thick and placed as apically as possibly. A piece of composite was attached to the disto-buccal aspect of UR1 to provide a larger engagement area. This was removed when treatment was completed. The result appeared to be tipping and possibly some bodily movement.

Figure 3 (a) Case 2, before treatment. (b) Case 2, after treatment

- Treatment time: 15 weeks.
- Number of appointments: 13 (appointment time ranged from 10 minutes for an impression to 30 minutes to fit and activate a new TARA).
- Number of TARAs: 4.
- Retention: Full arch passive thermoformed removable appliance.

Case 2

A Chinese male, aged 23 years presented with a Class I malocclusion with lingually instanding LL2 and LR2 (Figure 3a).

Treatment. Interproximal reduction (IPR) from mesial of LR4 to mesial of LL3 (mainly mesial of LR4 and LL3) allowed distal movement of LL2, LR3 and LR2, mesial movement of LL1 and LR1, and alignment of LL2 and LR2 (Figure 3b). Distal movement and mesial movement were achieved in a similar fashion to case 1. Alignment was accomplished by engaging the lingual surfaces of each tooth at two points; one above the cingulum and the other near the gingiva. Satisfactory tooth alignment was achieved in a relatively short time.

- Treatment time: 13 weeks.
- Number of appointments: 13.
- Number of TARAs: 4.
- Retention: 0.0195-inch Wildcat wire (GAC International Inc., Central Islip, NY., USA) bonded to all the lower anteriors from canine to canine.

Case 3

A Chinese female, aged 23 years presented with crowded anteriors, quite severely rotated UR1 and Class I buccal segments (Figure 4a). Expansion of the upper arch with proclination of the upper incisors was considered inappropriate in this case. The teeth were barrel-shaped with thick enamel at the contact points, making them suitable for substantial IPR.

Treatment. IPR all upper teeth from mesial of UR6 to mesial of UL6. The premolars and canines were sequentially distalized until sufficient room was accumulated to align the incisors. Figure 4b shows the accumulated spaces mesial to the canines. This case is near completion and included in this article to demonstrate the ability of this method to correct rotations (Figure 4c). Unfortunately, however, the patient moved away before treatment could be completed.

- Treatment time: 36 weeks.
- Number of appointments: 29.
- Number of TARAs: 9.

Discussion

The presented cases showed substantial improvement in dental alignment although one case could not be completed. Several types of tooth movements were demonstrated. Tipping in the bucco-lingual direction appeared to be the easiest to accomplish (case 2). Movement in the mesio-distal direction appeared to be more difficult and possibly due to the engagement areas being smaller (cases 1, 2 and 3). De-rotation was also demonstrated but treatment time was longer (case 3). Bodily movement has not been clearly demonstrated, but there was a hint of it in case 1. Torquing, extrusion and intrusion has not been attempted in the presented cases.

A relatively large increment of movement was achieved for each TARA through successive addition of the resilient lining. Adhesion of Triad Resiline to the Essix A+ plastic was excellent. No delamination was

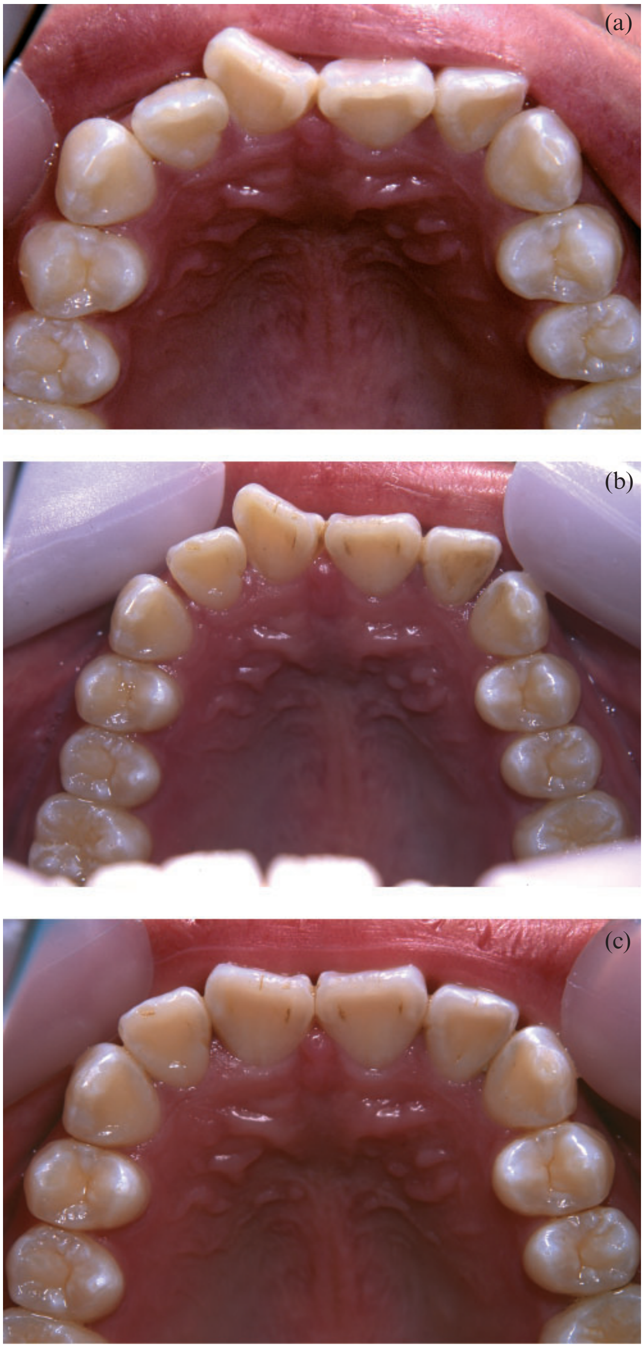

Figure 4 (a) Case 3, before treatment. (b) Case 3, intermediate stage. (c) Case 3, improved alignment of the incisors (NB. Patient did not complete treatment)

observed in any of the applications involved in the cases presented. The magnitude of forces generated by the resilient lining appeared well matched to the requirement for efficient tooth movement.

Substantial tooth movement was observed in as short a time as 7 days. The longest time that a TARA was used was 30 days. In cases treated by Invisalign® in other studies, the number of TARAs used ranged from 11 to 43 per arch and the treatment times ranged from 11 to 21 months.[6–9] The corresponding figures for cases in this report are: 4–9 TARAs per arch and 3–8.5 months. However, it should be stressed that case 1 only involved closing a central diastema and case 3 was close to completion, but not completed. TARAs with resilient lining appeared to be effective in performing a number of tooth movements to treat a range of mild to moderate Class I malocclusions, and may prove to be an expedient and inexpensive method to treat relapse cases. Compared with other TARAs, there may be substantial cost savings, partly due to the lack of need for royalty payments. A less obvious advantage of TARAs with resilient lining may be the flexibility in changing the treatment plan. There is no wastage when changing treatment plan during treatment because the TARAs are made one at a time. Although it seemed labour intensive over a short time, a lot of the procedures could be delegated to staff. More studies are required to examine the capability and cost effectiveness.

Further investigation into combining TARAs with resilient lining and computer fabrication should also be carried out. It is envisaged that the computer creates a precise path of movement, acting like an orthodontic bracket in guiding the tooth along, while the resilient lining provides the driving force. Such a hybrid system may be able to perform more complex tooth movements and used to treat a broader range of cases.

Conclusion

The three cases presented in this study demonstrated that localized use of resilient lining in TARAs appears to be a promising alternative to an established modality of TARA treatment in selected cases of mild to moderate Class I malocclusion. More studies are required to determine its cost effectiveness and to optimize the procedure and develop its full potential.

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