

Limitation of Aligners and How to Overcome Them

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Abstract

Aligners are a popular choice for many people seeking Orthodontic treatment due to their aesthetic appeal and convenience. They offer a more discreet alternative to traditional braces, as they are difficult to notice when worn. Along with that it provides an excellent substitute in the era of three-dimensional treatment planning. Clear aligners gradually exert gentle forces on the teeth, moving them incrementally until they reach the desired alignment. The aligner trays are designed to apply pressure to specific areas of your teeth, gradually shifting them into the correct position. The treatment process continues until all the teeth are properly aligned and bite is optimized. Earlier clear aligner treatment was considered to be utilized for the simpler cases, but with advancements it is proved that aligners can be one of the many possibilities for extraction cases, open bite, deep bite, interceptive and even for hybrid approaches. However, aligners may not be suitable for all Orthodontic treatment modalities, especially those requiring significant jaw alignment or complex tooth movements. This review focuses on the limitations and constraints of the type of movements provided by the clear aligners. Furthermore, this will assess the possibilities to overcome these obstacles for better performances in the near future.

Keywords: Aligners, Deep Bite, Extrusion, Intrusion, Tooth Movement, Transverse Expansion.

Introduction

With the upsurge of aesthetic demands, the use of clear aligners among Orthodontic patients has increased tremendously. Although aligners were first introduced by Kesling in 1945 to correct different forms of crowding, but the increase of its usage was noticed in the past two decades. The process of aligner therapy starts with an orthodontic consultation. They will assess the malocclusion and bite to determine if the patient is a good candidate for aligner treatment. If aligners are deemed suitable for the individual needs, the Orthodontist will take impressions, photographs, and x-rays of the teeth to create a 3D digital model. Using specialized software, the Orthodontist will plan the precise movement of the teeth throughout the treatment process. They will design a series of aligner trays, each slightly different from the previous one, that gradually shifts all the teeth into the desired position. The patient typically receives multiple sets of aligners, and each set is worn for a specified period, usually about two weeks, before moving on to the next set. One of the

advantages of aligners is their removability, which allows you to remove them while eating, brushing, and flossing. However, it's essential to wear them for the recommended 20-22 hours a day to ensure effective treatment. Compliance with wearing aligners as instructed is crucial for successful results. While aligners offer several advantages, they also have some limitations compared to other Orthodontic treatments. It is important to consider these limitations when deciding if aligners are the right choice for your Orthodontic treatment needs. Research has shown that clear aligner therapy is unable to perform few tooth movements with prior predictability that includes transverse expansion of maxilla, overbite control, molar distalization, rotation correction, extrusion, and intrusion. Apart from tooth movement, clear aligners also have some common disadvantages like speech impairment, patient compliance, cost considerations, periodontally compromised situations, etc. In this literature review we will discuss in detail about these

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drawbacks regarding the clear aligner therapy and various developments of hybrid approaches using a combination of different devices to overcome some of the most common limitations of removable appliances.

Transverse Expansion in Maxilla

Arch expansion, also known as Orthodontic expansion or palatal expansion, is a dental treatment technique used to widen the upper jaw (maxilla) or lower jaw (mandible) to correct certain dental and skeletal issues. In transverse plane, it is considered to be correct when the mesiobuccal cusp of upper molar occludes in the groove between the mesial and the middle cusp of the mandibular permanent first molar. A cross bite is formed when the mesiobuccal cusp tip is palatally inclined such that there is no occlusion seen. Cross bites can be skeletal or dental in nature (1). Arch expansion is primarily used to address a narrow dental arch, dental crowding or crossbite. It is one of the ways for gaining space and resolving crowding and cross bite. The expansion process typically involves the use of a dental device known as a palatal expander but achieving such a complex tooth movement with the help of aligners has been difficult in the near past. Although in cases with highly under torqued posteriors, research has shown that aligners reformed the malocclusion with uncontrolled tipping of the canines and premolars. This further improved the arch form and significantly increased the inter-canine, inter-premolar and inter-molar width (2). Meanwhile several systematic review and meta-analysis findings have revealed that the predictability of expansion for the lower arch ranges from 57% to 79% and 54% to 83% for the upper maxillary arch (1).

The expansion at the occlusal cusp is more predictable because the aligners move the teeth majorly with the aid of coronal tipping rather than bodily movement. In one of the RCTs performed by Galluccio G, results showed an average accuracy of efficacy of 70.88% in patients using aligner therapy from Invisalign (1). This expansion was primarily dental and therefore the relapse tendencies were higher.

This demonstrates that even though transverse expansion can be performed by clear aligners, correction is predominantly dental in the buccolingual inclinations and henceforth the periodontal conditions of the canine, premolars and molars must be kept in mind.

In young adolescent patients with transverse deficient hypoplasia, it is not ideal to achieve complete correction using just aligners (3). In these cases, an Orthodontic hybrid approach is necessary with the help of any skeletal anchorage with Orthopedic approach first followed by aligners. This can also be seen in adults, thus only after the transverse deficit has resolved, should the crowding be resolved. This also decreases the risk of premature contacts and TMJ discrepancies.

Rotational Movements

Known as one of the toughest Orthodontic movements, achieving rotational correction is usually very difficult even in fixed mechanotherapy. It's important to note that rotational movements with aligners and attachments is more effective for minor to moderate rotations. Severe rotations or complex cases may require alternative Orthodontic interventions, such as braces or additional dental procedures. Mandibular canines are the most difficult tooth to control with aligners because of their morphology. It is notable that the accuracy of rotations more than 15° for canines and premolars may drop the anticipated movements to percentages as low as 18.8% and 23.6%, subsequently (3).

This is due to the fact that they are unable to get a grip on the cylindrical shaped teeth. As we are well aware that aligner therapy works on two primary mechanisms, one is shaping moulding effect, and the other is auxiliary elements such as attachments and power ridges. That is the reason why canines and premolars especially the mandibular canines are difficult to create a force couple and derotate. Most of the research work on aligners have been done with Invisalign CAT and one of such research by Castrolfo et al suggests that, unlike popular beliefs it's the first molar that showed excellent predictability with rotational movements. Upper lateral incisors, canines and premolars are difficult

to control because of their anatomical structure. The simplest conclusion that they drew was that the design of attachments was not adequate to control the prescribed movements (1). And lower canine had one of the worst rotational predictabilities.

Several remedies have now been discovered for this problem. When it comes to rotational movements, adjusts like buttons, and power chains along with the attachments comes to the rescue. To increase the grip and make the movements more predictable we need to first gain the space required for derotating then use that for guiding the movement of teeth. This not only increases the predictability of the outcome, but also increases the patient's comfort by decreasing the treatment timing.

Distalization of Molars

Molar distalization is a dental procedure aimed at moving molars backward in the dental arch to create space or correct protrusion. It is routinely achieved for treating mild to moderate skeletal Class II cases. The upper molars can be distalized by utilizing extra and intraoral forces.

For instance, the extra oral forces might include facemasks and different kind of headgears, that has been frequently used since the 1950's. Along with that the newer inventions in intra oral forces involves bone anchored screws and plates, that have led to create an easier path for distalization. Several case reports have shown the probability of obtaining class II correction with a sequential maxillary molar distalization especially in adolescent patients using the Clear aligner therapy (CAT). Having said that they have a mean accuracy of 88.4% with attachments and 86.9% without attachments, henceforth nearly 2–3 mm of distalization is achievable with CAT, in addition to that having a good control over the sagittal craniofacial parameters, mesio-distal angulation of molars, and anchor loss (4). Rivera and Simone *et al* found out that a maximum of 3mm of molar distalization was seen in patients using CAT. Most of the movements were translation and no changes in the facial height was observed (5). And it has come to the attention that most of these movements are translation rather than tipping.

In the randomised prospective trial by Lione, it was seen that aligners can also be replaced instead of the older appliances like Pendulum as a valid alternative (6). Nonetheless, aplastic maxilla or mandible with transverse as well as sagittal discrepancies need rapid expansion using devices like maxillary arch expansion and constriction (MARPE) appliance or HYRAX with bone anchored mini screws. These will enable us to resolve the transversal issues prior to using aligner therapy. Aligner therapy in conjunction with Class 2 elastics and composite attachments can provide an excellent alternative to non-extraction distalization cases.

Extrusion and Intrusion

Since the beginning of the aligner era the vertical movement of teeth has been unpredictable, be it extruding or intruding the tooth. For example, in more complicated tooth movements like in treating open bite, these removable thermoplastic aligners may be beneficial. In treating malocclusions, aligners do not produce the same extrusive effect on the posterior teeth as would occur with conventional fixed orthodontics (6). This is achieved by a relative movement of intrusion and extrusion. The closing of open bite was attained with the assistance of molar intrusion, use of inter-proximal reduction (IPR) and attachments for incisor excursive movements (6). Several studies have shown a significant retraction and extrusion in both the maxillary and mandibular incisors. In the study published by Heeyon Suh *et al*, 94% of patients achieved a positive overbite, with an average final overbite of 1.1 ± 0.8 mm and using only clear aligners, there was an average maxillary molar intrusion of 0.36 ± 0.58 mm (7). It was accompanied by a counterclockwise rotation of the mandible leading to a reduced lower anterior facial height. Most of this is achieved in less than 20 clear aligner sets. Yet extrusion is known to be one of the most difficult and non-predictable movements to achieve along with rotation correction. There is currently insufficient evidence regarding the impact of attachments on intrusion and extrusion, although it is noticed that attachments may enhance the intrusion movements.

Deep Bite Control

Primarily it is corrected using three mechanisms: the watermelon seed effect, the bite ramps and the drawbridge effect. Essentially the counterpoint of open bite is the deep bite correction, which is again unpredictable for the lack of grip on the anchoring tooth.

Thus the “watermelon seed effect” aids for the aligners to apply a compressive force from all the surfaces including buccal, lingual and occlusal surface (8). However, as simple as it might sound the tooth anatomy is not symmetrical, therefore the force applied is not always even (7). Further, this disproportion will create an unwanted moment. If this moment can be predicted beforehand, we can use this “pressure areas” to provide additional forces.

Disocclusion in the oral cavity is one of the most important steps to any treatment of malocclusion. Here, the bite ramps which play an important role in removing unwanted occlusal forces can be utilized (8). These bite ramps in the form of lingual prominences might be attached into the palatal sides of the anterior teeth for better extrusion of maxillary and mandibular posteriors or molars.

Attachments for anchorage are crucial for effectively applying pressure to intrude anterior teeth without causing the aligners to disengage from posterior teeth, while also facilitating posterior extrusion. When anterior tooth intrusion is linked with proclination, addressing a deep bite becomes more manageable. Pasciuti *et al* employed a new protocol of frog staging for deep bite correction (7). Frog staging is a technique in which intrusion is first designed on the lower canines followed by incisors then again on canines, and so on. This may require a greater number of aligners compared to traditional methods but could enhance predictability. Lastly the drawbridge effect, which is nothing but simple tipping moment of the anteriors that lead to pseudo correction of the overbite (8). Does not involve absolute intrusion rather provides a simulated correction of the open or deep bite.

Root Movements

Torqueing or pure root movements are known to be one of the most difficult movements to achieve

in Orthodontics. Tipping, or more specifically uncontrolled tipping is considered as the ‘defective’ tooth movement in Orthodontics which is usually observed with root movements and CAT. To date, no disseminated data could be found regarding the efficacy of root movements and incisor torque with removable thermoplastic aligners (9). The standard Orthodontic appliances and wires do not completely fill the bracket slots, so that the wire is able to swirl around, leading to loss of moment, known as play. Moreover, the size and quality of the wire the bracket material that is whether it is polycarbonate brackets or metal and ceramic brackets along with their designs, the inter-bracket distance, the vertical and horizontal positioning of the bracket as well as the method of ligation all influence the torque movement of the long-influenced fixed appliances. All of which is unseen with clear aligner therapy.

In the retrospective study by Raj Gaddam, it was found out that the difference between the predicted and achieved torque was statistically significant. Torque was under-expressed when the teeth were moving labially, and fully or over-expressed when moved lingually, indicating Invisalign therapy’s inefficiency in the labiolingual movement of root (10). The thickness of the tray and the type of attachment used for root movement is one of the modifications which can be done but very few evidence is found regarding the expression of torque with aligners and therefore more clinical trials are required to confirm.

Others

These were the limitations based on biomechanics, the more known disadvantages include patient compliance and cost effectiveness. As any removable appliance would be clear aligner therapy among other things needs for exponential amount of patient obedience. Successful treatment with clear aligners requires a high level of patient compliance and discipline.

Because these aligner trays are custom made and completely dependent on the patients to wear and change from time to time, it becomes difficult to track and monitor them for proper advancements. Unlike fixed mechanotherapy CAT demands the entire treatment planning with the initial 3-D

scans. This has come up to be a difficulty with practitioners who are not well versed with aligners. OTM staging with different software needs to be given more attention and research. One of the major drawbacks of CAT is the inability to achieve the predictions from the original treatment planning, which then does not integrate with the patient's expectation.

Another disadvantage is the prices of these aligner treatments. In comparison to the regular treatments, they cost over four to five times more, which becomes a hesitation for few patients. Meanwhile fixed Orthodontic treatments are more pocket friendly.

Post orthodontic treatment stability for clear aligners is one such question that is asked by both the patients and orthodontists. One study by Kuncio et al between the fixed orthodontic therapy and Invisalign suggested that in the period of observation, Invisalign relapsed more than the conventional brackets (11). Very few long-term studies have been conducted and limited literature is found on this topic.

Discussion and Conclusion

Clear aligners have revolutionized the field of Orthodontics by providing a convenient and aesthetically pleasing alternative to traditional braces. Made of transparent plastic material, making them virtually invisible when worn, this discreet nature of clear aligners appeals to individuals who desire a more cosmetically pleasing Orthodontic treatment option. Clear aligners support improved oral hygiene and periodontal health, decrease plaque buildup and the occurrence of white spot lesions.

The field of aligner Orthodontics is constantly evolving, with ongoing research and development focused on improving treatment outcomes and expanding the range of cases that can be effectively treated with aligners. As new technologies and techniques emerge, the limitations of clear aligners are being addressed. The schedule for changing aligners should be tailored to the specific tooth movements required during treatment. Typically, a 7-day interval between changing aligners is suitable for most adjustments. However, certain movements, such as controlling buccolingual

inclination of molars, rotating lower canines and bicuspid, and managing rotation and intrusion in lower molars, may necessitate a longer interval of 14 days between aligner changes (12). This extended time frame allows for more precise control over these tooth movements, ensuring optimal alignment and treatment outcomes. Orthodontists can involve combining CAT with hybrid options with newer innovative Orthodontic devices to achieve optimal and predictable outcomes.

Abbreviation

RCT - Randomised controlled trials (RCT); Clear Aligner Therapy (CAT); Orthodontic Tooth Movement (OTM); Three Dimensional (3D).

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AC contributed towards manuscript preparation. SM contributed towards manuscript drafting and editing. AP contributed towards manuscript revision.

Conflict of Interest

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