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Are Clear Aligners Better than the Conventional Orthodontic Fixed Appliances?

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Abstract

Clear aligner therapy (CAT) has become an attractive alternative for orthodontic treatment as more adolescents and young adults pursue othodontic care. CAT is comprised of removable transparent appliances that offer a more aesthetic appearance to prospective patients. Recent studies have shown that CAT efficiency and efficacy for orthodontic procedures for cases of mild to moderate malocclusions are of equal or greater caliber to those of conventional fixed appliances. Clear aligners are also found to be less painful, better for periodontal health, and more accessible in comparison with fixed appliances. For those meeting the criteria for CAT, clear aligners may be a worthwhile course of treatment to explore.

Introduction

The pursuit of orthodontic treatment for adolescents and young adults has become a standard in regard to oral aesthetics and care. Conventional fixed appliances made from steel and ceramics are commonplace due to their years of applied practice and cost-effective treatment. However, along with the use of traditional orthodontic fixed appliances are shortcomings that impair the orthodontic experience. Clear aligners are a rather novel orthodontic device that are becoming attractive as an alternative for orthodontic procedure due to their aesthetics and accessibility.

In 1944, TP Orthodontics introduced the idea of removable orthodontic appliances meant for moderate cases of teeth repositioning. The approval for Align technology, the use of clear aligners in orthodontic treatment, by the FDA in 1998 spearheaded the popularity of CAT including Invisalign. CAT comprises of a variety of different orthodontic appliances which differ in their construction, duration of use, and effectiveness in treating oral malocclusions. The transparent plastic aligners offer diverse courses of treatment and with recent technology, can be employed to treat an assortment of problems in dental orthopedics.

Assessment of CAT applicability and its flaws is challenged by its rapid advancements in design and composition. Improvement of imaging technology and clear thermoplastic materials increases the comfort of wear while minimizing pain and duration of orthodontic treatment. More sophisticated CAT systems are available for increasingly complex oral malocclusions such as inter arch changes where additional attachments or alternative geometries are necessary. Using Invisalign or similar technologies provides patients a viable substitute to fixed braces. Essentially any form of dental malocclusion can now be successfully managed using clear aligner therapy (Weir, 2017).

Orthodontic treatments applied with standard fixed appliances, while effective, are uncomfortable and unsightly for the patient. Invisalign wearers perceived significantly lower pain levels than those being treated with metal appliances, particularly in the earlier stages of treatment (Cardoso, et al. 2020). It was also noted that fixed appliances may contribute to inflammation of the gums and aggravate periodontal health and gingivitis, a bacterial infection of the gums. CAT offers an appealing substitute in orthodontic therapy, although limited to mild to moderate malocclusion conditions. Is the treatment efficacy and safety of clear aligners better than the conventional orthodontic fixed appliances? This review is aimed at determining a better choice of orthodontic therapy to patients seeking dental orthopedic care.

Method

Peer reviewed academic journals and scientific articles were used to obtain research on Clear Aligner Therapy and fixed appliances in orthodontic procedures. Various data were used to review and provide evidence of the legitimacy of the research question. Proquest, Ebsco, and Medline databases were accessed through Touro College Library online and Pubmed.

Discussion:

Features, Materials, and Mechanics of Clear Aligners

The biomechanical characteristics of Clear Aligner Therapy are influenced by the various properties of its thermoplastic composition, texture, and fit. The series of aligner treatments can be fashioned to be constructed using one aligner material, or to be made from different aligner components as therapy progresses. Clear aligner formation can be vacuum or pressure modeled. Both methods rely on air pressure for the structure of the product. However, the pressure-based design involves higher pressures of up to 100 psi which is equated with enhanced precision of fit and force efficiency of the aligner around the tooth surface. Impressions, usually composed of polyvinyl siloxane, are taken by the clinician to send to a laboratory where 3D scanning technology is used to manufacture the appliances. CAD-CAM technology allows for the model to be adjusted for the individual stages of treatment. Accuracy of the model is critical for the efficacy of the subsequent tooth rearrangement. Some orthodontists will offer in-house 3D printing of the appliances, while others have them assembled and shipped from a specialized laboratory.

CAT is directed at maintaining proper adhesion of the

aligner to the teeth while transmitting sufficient force that allows for the movement of the teeth in a predictable trajectory. This is performed while attempting to minimize discomfort of the patient pursuing treatment. Commonly used materials for clear aligners are polyester, polyurethane, and polyethylene glycol terephthalate (PETG). Appliances composed of polyurethane tested to be of higher hardness and indentation modulus, measuring greater levels of elasticity than PETG-based products (Putrino, et al. 2021). Clinical behavior can be anticipated prior to treatment by analyzing the content and configuration of aligner appliances.

The thickness of the thermoplastic materials used in CAT can either be predetermined by manufacturers of the product or can be modified based on the course of treatment. Thickness can also be alternately modified in order to apply forces of fluctuating intensity during treatment. The width of the aligner, typically 0.5, 0.625, or 0.75mm, does not have a significant effect on general examined tooth movements. However, incrementing thickness does adversely impact more complex malocclusions.

The pressure exerted on the tooth by the material enables the aligner to stimulate movement. The presence of composite resin buttons placed on the buccal or palatal surface of one or more teeth guides the displacement of the bridgework. Specificity of the structure of the resin attachments depends on their function. Horizontal shaped attachments would be used to increase aligner stability of premolars and incisors while beveled rectangular attachments are used for aligners in cases of a deep bite. The interactions between the aligner, attachment, and the tooth necessitates precision to achieve effective movement. Aligner systems can also integrate auxiliary elements, such as mini-screws and elastics, for increased corrections and refinements.

Differentiation Among Clear Aligner Products

There are many different types of clear aligners now available that fall under the umbrella of CAT. For minor tooth movements (MTM), where clinical applicability is limited, orthodontic products such as MTM Clear Aligner, Originator, and Simpli 5 offer a less expensive and quicker substitute to other CAT appliances. Aligners from Suresmile, 3 Shape, and Orchestrate allow for completely in-house fabrication and production of the appliance using 3D treatment planning software. For more comprehensive systems, where 3D CAD-CAM treatment and bonded resin attachments are incorporated, popular companies like Invisalign, ClearCorrect, and eClinger are providing aligners for more complex tooth movement. Invisalign is the most intricate CAT appliance available, focusing on a high level of precision using 3D model manipulation and a sophisticated appliance design. Invisalign products have built in pressure points to aid tooth intrusion movements as well as detailed attachment types and precision cuts for ease of wear. Different brands of clear aligners have consistent differences between their products and will obtain diverse results. The strategy and design of a clear aligner product converge in determining the capability of a system of aligners for a specific treatment.

Fixed Appliances - Background and Categories

Fixed orthodontic appliances are the most widely used, producing precise tooth movements after 18-24 months of treatment. Following any fixed orthodontic therapy, the patient must participate in a retention system. Although there are multiple different brands of fixed appliances available, the function between the products don't really vary. Conventional metal fixed appliances, often termed "train tracks", are most popular among children and adolescents (British Orthodontic Society, 2014). The metal is typically composed of stainless steel and attached onto the teeth using a tooth-colored composite resin. An archwire is woven into the brackets using silver or colored elastic rings. The attachments are easily detached and therefore care must be taken to avoid consuming hard or sticky foods that can disrupt the treatment. As the tooth movement progresses, thicker wires are enforced to apply greater force onto the teeth and "tighten" the appliance. At the completion of treatment, the appliance is simply removed from the teeth of the patient.

Attachments may also be formed from a hard ceramic material, ceramic fixed appliances, as an alternative for a more aesthetic look for adults. The ceramic is designed to blend with the tooth color and the orthodontic wires can also be made to match the shade of the teeth, further improving the appearance. Although similar in function and effectiveness to fixed metal appliances, ceramic appliances are often discouraged from use on the lower teeth since the hard material can potentially damage opposing teeth contacting the attachments. Additionally, ceramic appliances are more challenging to remove, although unlikely to cause damage to the teeth.

Self-limiting appliances, whether produced from metal or ceramic, use an integral clip mechanism to hold the position of the wire of the appliance instead of the traditional elastics. The clip allows the wire to slide more freely and reduces the time necessary to change the wire. Lingual fixed appliances differ from other fixed appliances as they are attached to the inside surface of the teeth and are externally invisible. Despite them being adept at achieving high quality results, lingual appliances may

involve tongue soreness, difficulty speaking, and maintenance problems for the patient. Furthermore, there is a considerable increase in the cost of treatment due to the manufacturing and additional clinical time required.

Clear Aligner Efficacy and Outcome- Data and Case Reviews

The diversification of the primary characteristics of clear aligners has improved their indications and capabilities. Initially, clear aligners were limited to leveling and the alignment of arches. Today, even more intricate cases can be managed with clear aligners. Several factors must be considered in determining successful tooth movement when evaluating the results of CAT. The material and thickness of the aligner, the shape and position of the attachments, and the techniques used for the production of the aligner heavily influence the outcomes of treatment. Moreover, the individual patient's crown and root morphology as well as bone density affect the development of orthodontic therapy. Therefore, there is a variance among different clear aligner systems regarding their eligibility, efficacy, and predictability.

For oral malocclusions of greater complexity, CAT is coupled with additional orthodontic techniques such as additional attachments, auxiliary tools, and altered geometries to provide better control of movement and to improve treatment results. The use of fixed expanders, lingual buttons, intermaxillary elastics, power arms, and temporary anchorage devices can be integrated into more sophisticated aligner therapies for more difficult movements. CAT is relatively predictable for treatment of simple malocclusions such as cases of intrusion of the anterior teeth and for control of posterior buccolingual inclination, crossbite of the premolar and molar teeth (Buschang et al, 2014). However, areas of rotation and anterior buccolingual inclination are more problematic.

The efficacy of Clear Aligner Therapy in terms of alignment and straightening of the arches in cases of mild to moderate crowding is superior to the results obtained by fixed appliances. Additionally, levels of relapse are higher in fixed appliances than those treated with CAT. A study conducted on the Nuvola aligner system noted that although aligners aren't capable of significant root movement, they are useful for crown tilting movement of the tooth and for torque movements of canines and central and lateral incisors (Tepedino et al, 2018). A case series on preliminary treatment of anterior crossbite in young children observed that clear aligners were effective in treating the malocclusion, with little discomfort experienced by the patients in comparison to those of fixed appliances (Staderini et al, 2020). The Model Grading System (MGS) of the American Board of Orthodontics evaluated that Invisalign treatment was active in correcting tooth alignment and buccolingual inclination when used in less severe malocclusions (Kassas et al, 2013). Invisalign achieves this bodily movement through the use of Power Ridge, an oral attachment (Simon et al, 2014). Overall treatment efficacy is additionally influenced by the staging and total amount of planned movement of the aligner.

The effectiveness of clear aligners is expressed by the device's ability to perform complicated dental movement in a predictable fashion in equivalent or greater magnitude to the performance of fixed appliances. Progression of aligner and tooth cooperation is contingent upon the precision of the operative protocol. A clinical trial investigating CAT in controlling vertical buccal occlusion revealed that aligners were successful in regulating the tooth movement. The Orthodontics Objective Grading System (OGS) discovered similar average scores for CAT (-4.9) and fixed appliances (-4.5) for treating the malocclusion (Rossini et al. 2015). It was also reported that CAT and fixed appliances earned close OGS scores in regard to root angulation, the angle formed by the intersection of the tooth root and the long axes of the crown, at the end of treatment. The presence of an attachment on the tooth surface and aligner geometries also allows for more accurate bodily movement of the upper molars, specifically when a distalization movement of 1.5 mm is prescribed (Rossini et al, 2015). However, data shows that currently clear aligners are not recommended to treat an open bite, the inability to make contact with the upper and lower teeth, as well as for severe cases of extrusion.

Pain Level Comparisons Between Clear Aligners and Fixed Appliances- QoL

Orthodontic treatment involves a variable degree of pain. Pain is a subjective response that is dependent on multiple factors such as age, gender, stress, tolerance, and applied force. A patient's individual experience with pain during treatment has a significant impact on their quality of life. Pain directly influences the patient satisfaction of treatment and is often the cause for treatment discontinuation. Pain is felt to some extent by 95% of patients at individual stages of treatment. Additionally, fear of pain is a factor in preventing many from pursuing orthodontic treatment. Therefore, the assessment of the difference in pain levels between clear aligners and fixed appliances while undergoing orthodontic treatment is of immense importance.

Treatment with fixed appliances is commonly perceived as painful and uncomfortable, particularly during the twenty-four hours after arch insertion. Pain and discomfort experienced by CAT in the first week of therapy was perceived to be substantially reduced in comparison

to those of fixed appliances. After the first few months of treatment, as patients adjust, the considerable pain between modes of treatment become less disproportionate. However, quality of life for aligner patients estimates better results in regard to eating and chewing due to CAT's removable nature. Removable appliances generate intermittent forces, allowing the gum tissue to adapt before the compressive forces are reapplied. It is necessary to note that the type of appliance used within CAT will have its own specific force applied, impacting the discomfort experienced by patients.

A study evaluating pain levels in self-ligating appliances from the companies Speed and Damon with Invisalign reported that the group using fixed appliances presented increased levels of pain in comparison to the Invisalign group (Masi-Damois, 2015). A different study revealed that lingual appliances are associated with more severe pain than those using clear aligners. Although the CAT patients complained of elevated levels of pain for a few days after insertion, the oral symptoms and general disturbances felt throughout treatment were relatively low (Shalish et al, 2011). Analgesic consumption, which function as pain relievers, is also higher in patients with fixed appliances. The sensation of orthodontic pain is attributed to the changes in blood flow caused by the force of the appliance, compressing the periodontal ligament. During the first days of treatment, inflammatory mediators such as prostaglandins and interleukins are released. Analgesics reduce the inflammatory process, thereby reducing pain felt by patients. The pattern of pain observed is explained by the levels of the mediators in the gingival cervical fluid, with a peak twenty-four hours after insertion of the appliance and leveling off after seven days.

The search for more comfortable approaches to orthodontic treatment has led to increased CAT use and techniques. Patients treated with clear aligners reported an improved quality of life. Reinsertion of aligners usually occurs between every 15-30 days of treatment, and lower pain levels were experienced at each subsequent activation. Additionally, the aligners can be removed by the patients themselves for short-term pain relief. The type of malocclusion is relevant in estimating pain during treatment. The more serious the malocclusion, the higher the likelihood of pain and discomfort. Orthodontic professionals should guide and inform their patients on how to best manage and alleviate their pain depending on the course of treatment.

Aesthetics

The increase in adults pursuing orthodontic treatment has led to a corresponding rise in demand for dental appliances that are more aesthetic than the conventional fixed appliances. Many patients who specifically seek CAT for their orthodontic treatment have stated that the aesthetic of the appliance was their primary concern. Adults and adolescents alike are worried about their appearance and fixed appliances may evoke feelings of anxiety over one's dentofacial appearance. Therefore, providing more aesthetic alternatives for orthodontic treatment, such as CAT which blends with the crown anatomy, allows patients to improve their teeth and any malocclusions without the expense of their mental health.

In younger children and adolescents who require orthodontic treatment, where parents are the ones scheduling and determining the treatments, a main concern was that the effect of the appearance and speech impairment caused by fixed appliances would harm the self-confidence of the patient. Often, a young patient may experience teasing and embarrassment in public due to their image. The use of clear aligners in improving dentition should be taken into consideration as a viable and comfortable alternative for younger patients. CAT allows children and young adults to still participate in all social activities without any aesthetic restraints. However, discipline in wearing the removable device is important and should be discussed with the parent by the orthodontist before treatment.

The appliance brand and material composition affect the attractiveness of the appliance. Attractiveness ratings ranked clear aligners at the top of the hierarchy, followed by ceramic and self-ligating appliances and afterwards, fixed metal appliances (Rosvall et al, 2009). The increased willingness-to-pay value for CAT indicates that patients are willing to pay more money for more aesthetic orthodontic appliances. Accordingly, the aesthetics of clear aligners such as Invisalign are superior to conventional fixed appliances.

Oral and Periodontal Health-Associated Conditions

Orthodontic treatment can have a significant impact on periodontal and oral health. Periodontal diseases are serious gum infections that can cause damage to the bone and soft tissue surrounding the tooth. Gingivitis, bleeding, as well as alveolar bone loss are common periodontal related conditions. The main causative agent for periodontal diseases is the bacteria that accumulates in dental plaque. Fixed appliances activate an increase in plaque during treatment. Oral hygiene, such as daily brushing and flossing, is the primary defense in minimizing dental plaque and controlling gingival inflammation. Maintenance of a healthy periodontium is dependent upon good oral upkeep. However, fixed appliances and wires make oral

hygiene and plaque control difficult. Additionally, orthodontic treatment can stimulate periodontal disease by increasing bacterial aggregation due to plaque buildup. Patients with active periodontal issues pursuing orthodontic treatment with conventional fixed appliances are at risk for additional periodontal disruption.

Use of clear aligner therapies has increased as adults more frequently seek orthodontic treatment. An analysis on oral health in CAT reported that patients being treated with fixed appliances had substantially higher plaque index scores than those with clear aligners (Han, 2015). This may be a result of the aligners being removable, thus oral hygiene isn't restricted. Patients wearing traditional braces must meticulously brush each bracket and floss around the wires to prevent plaque accretion; this can be very difficult. The regular adjustments involved can create plaque retention sites and lead to white spot lesions and periodontitis. Growth of subgingival plaque greatly increases the discomfort of the patient. A twelve-month study associated CAT with decreased levels of periodontopathic bacteria and increased oral health in comparison to treatments with fixed appliances (Weir, 2017). Therefore, in order to inhibit periodontal complications, removable orthodontic therapies should be strongly considered.

Contemporary fixed appliances enforce a light but continuous force to the teeth to manage orthodontic movement. This mechanotherapy is characterized by the formation of new layers of bone in the soft tissue as movement progresses resulting in alveolar bone resorption. In comparison, CAT applies intermittent forces on the teeth, inducing activation of receptors. For example, kappa-B ligand activity through IL-1ß expression, reducing damage in periodontal ligament cells (Han, 2015). In cases of severely inclined teeth, where CAT is not a viable course of action, then fixed appliances can be coupled with clear aligners for orthodontic and periodontic treatment.

In a study evaluating periodontal health in those using the Invisalign system and those being treated with fixed lingual appliances, thirty patients were examined at three consecutive times for their oral health status. The patients' gingiva, papillary bleeding index, plaque, and sulcus probing depth were measured and compared. At the end of the evaluation, Invisalign patients demonstrated superior periodontal indices with exception to the sulcus probing depths which were similar in both groups. Despite the teeth and parts of the gingiva being covered with the clear aligner for around 20 hours a day, the periodontal risk is lower than those of fixed appliance due to CAT's removability (Miethke & Brauner, 2007).

Clear aligner therapy allows its patients to clean the appliance out of the mouth in addition to using dental floss, which improves dental hygiene. The CAT system can control the amount of force exerted on the tooth due to the aligner covering a large part of the crown. Supragingival plaque destroying periodontal tissue can thereby be avoided as the teeth undergo movement. Treatment using CAT is a safer and preferable method for periodontal tissues than the techniques of conventional fixed appliances.

Efficiency

As clear aligners and their features have evolved and diversified, their efficiency has increased. Treatment with CAT presents advantages such as decreased chair time and treatment duration for patients with mild to moderate malocclusions. In the occurrence of a lost or damaged aligner, replacement usually takes under 2 weeks while the patient continues to wear an old aligner in the meantime in order to avoid prolonging treatment. In addition, aside from misplacing an aligner, there are relatively few emergencies when being treated with clear aligners, unlike therapy with fixed appliances. Conventional appliances often experience a broken wire or removed bracket that can cause the patient discomfort or prevent them from eating.

Treatment with fixed appliances requires frequent visits to the clinician for adjustments and monitoring as tooth movement progresses. In contrast, patients using clear aligners such as Invisalign, are generally given a few sets of aligners at once, and only come in every few months to regulate the treatment. Reduced chair time with CAT over conventional appliances was confirmed in a study, promoting the efficiency of clear aligners (Buschang et al., 2014). The time period of therapy for CAT is generally either in-line with conventional approaches or shorter. It is important to recognize however that poor compliance in wearing the removable appliance, specifically in younger patients, can prolong treatment duration.

Ultimately, the effectiveness of the aligner to achieve dental torque movements with accuracy affects its efficiency in treatment. With CAT, the final aligner can be used as a retainer for the following months after orthodontic treatment, instead of using an additional retention appliance for the next couple of years. The short treatment time and comfortability is attractive to busy adults as well as for parents of young patients who seek rapid improvement in their tooth repositioning and movement. Clear aligners offer an efficient and accessible mode of treatment to its patients.

Clear Aligner Limitations and Deterioration

The force produced by CAT is dependent on the thermoplastic material's initial mechanical properties and

stiffness. The aligner material and its properties can therefore affect treatment outcomes. Intraoral aging can modify the mechanotherapy of the aligner and compromise the efficacy of treatment and the overall force delivery. Intraorally aged aligners have morphological modifications such as localized calcification, discoloration, and abrasion at cusp tips. There are no detectable chemical changes, however, the mechanical properties of CAT are adversely affected by intraoral aging.

There is a detrimental effect on the surface roughness of clear aligners due to the material composition of the appliance during the first week of treatment. The deterioration of the mechanical properties of Invisalign aligners is attributed to its polyurethane's inherent structural instability. Additionally, attachments introduced into the aligner system for increased control of tooth movements results in wear and surface alteration of the aligner. Although exerted aligner forces are decayed during treatment, there is no clinical evidence of it significantly impacting the efficacy of tooth movement.

Taking into account the device's mechanical properties, it was found that aligners with a 2-week activation period resulted in the best measures of tooth alignment improvement (Bradley et al., 2015). The abbreviated period for intraoral aging combined with high oral care minimizes CAT mechanical alterations. Therefore, patient compliance regarding oral hygiene and wear is critical for clear aligner efficacy. There are relatively few clinical studies on clear aligner systems, therefore there is a need for further experimental data and scientific research for a more comprehensive understanding of CAT and its limitations.

Tele Orthodontics/Covid-19

The Coronavirus pandemic required all non-emergency medical related appointments and procedures to be limited and/or postponed in order to avoid the possible spread of the infection. Orthodontic practices suspended patient visits as well as the management of orthodontic emergencies such as detachment of bands or brackets for fixed appliances. Orthodontists began to employ professional platforms for "tele-orthodontics" as a substitute for in-person regulation of their patients' orthodontic treatment. To conduct the remote visits, clinicians relied on video calls and mobile messaging to manage their patients' dental activity. COVID-19 highlighted the need for remote virtual dental care in cases of distance or minor emergencies. In times of crisis, mobile technology offers patients the ability to regulate their intra-oral development in a safe and effective manner. Tele-orthodontics can also be useful for when a patient would like to report an issue prior to the next visit or for questions in regard to treatment.

Treatment with fixed appliances necessitates frequent in-person visits for adjustments and assessment of pain and gingival health. In contrast, clear aligners, as a result of their efficient treatment period, minimal chair time, and rare emergencies, are optimal for tele-orthodontics. The tele-orthodontic system is a significant clinical advancement that would allow patients who are disabled, sick, or unable to travel to receive orthodontic care. In clinical cases eligible for CAT treatment, patients unavailable for regular visits should strongly consider treatments with clear aligners. Post-pandemic orthodontics via tele-orthodontic care grants reduced social contact and promotes safe dental treatment in a healthy and professional environment.

Conclusion

It is of immense value to search for alternatives in treatment of orthodontia in order to alleviate some of the current adverse effects of orthodontic practice. CAT may be a satisfactory option to explore if deemed tantamount in effectiveness or superior to standard orthodontic appliances due to their aesthetic look, comfortability, and oral health benefits. Clear aligners offer its patients a removable device that improves appearance without compromising periodontal health or comfort. CAT is therefore a better course of treatment for cases of mild to moderate malocclusion, however, other modes of treatment should be explored for more complex dental movements.

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