

Unraveling the Role of Attachments in Clear Aligner Therapy

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Abstract:- The popularity of clear aligner treatments (CATs) have risen multiple folds in the past decade or so due to a demand for an aesthetic appeal and comfort. However, CATs have limitations in achieving certain tooth movements. To enhance predictability, resin attachments have been introduced. This review examines various types of attachments used with CATs, exploring their configurations, efficacy, and optimal placement. Selecting appropriate attachments based on the malocclusion is crucial for precise and stable treatment outcomes. Understanding and utilizing these auxiliary features can optimize the effectiveness of clear aligner treatments, meeting the expectations of adult patients seeking discreet and comfortable orthodontic solutions.

Keywords:- Clear Aligner therapy, attachments, Invisalign, aligner attachments

I. INTRODUCTION

In recent years, there has been a growing trend among adult patients seeking orthodontic treatment. These patients often express a desire for treatment options that are both aesthetically pleasing and comfortable, rather than opting for conventional fixed appliances.¹ They are looking for alternatives that offer an improved appearance during treatment and minimize any potential discomfort or inconvenience associated with traditional braces.

The history of clear aligners dates back to the introduction of intraoral tooth positioners by Kesling² which were resilient dental appliances capable of urging teeth into preselected positions.

In 1998, Align Technology Inc. (Santa Clara, CA, USA) introduced the clear aligners, which we now know as Invisalign®.³ These are a series of custom-made clear plastic overlay appliances called “aligners” that move the teeth according to the projected stages of movement.⁴

Initially, clear aligner treatments (CATs) were primarily used for treating mild cases of dental crowding. But modern aligners have demonstrated the capability to perform a range of orthodontic movements beyond mild crowding cases. These include leveling and alignment,

intrusion of anterior teeth, and upper molar distalization, offering patients effective treatment options with predictable outcomes.⁵ However, CATs (clear aligner treatments) have certain limitations when it comes to achieving specific tooth movements. Some tooth movements, such as extrusion of anterior teeth, correction of severe rotations, inclination of posterior teeth, torque formation, and closing of spaces larger than 5 mm, are generally more challenging to accomplish with CATs. These movements often require more precise control and force application, which can be difficult to achieve with aligners alone.

In order to address the limitations of clear aligner treatments (CATs) and enhance the predictability of tooth movement, various auxiliary features have been proposed. These features include resin attachments, elastics, and interproximal reductions.

Resin attachments facilitate more complex tooth movements, one of which is translation. It has been established that the utilization of attachments is now recognized as an integral and necessary component of CATs.

This review aims to comprehensively examine the diverse types of attachments utilized in conjunction with clear aligner treatments (CATs). The focus will be on exploring their distinct configurations, dimensions, and optimal placement locations, as well as assessing their efficacy. Additionally, this review will highlight the significance of selecting specific types of attachments based on the particular malocclusion being treated, ensuring the achievement of the utmost precision, accuracy, and long-term stability in treatment outcomes.

II. DISCUSSION

Composite attachments are small auxiliary composite buttons with a defined geometry that are attached to the surface of the teeth to improve both the retention of clear aligners and transmission of force from clear aligners to the teeth.⁶

There are currently two types of Invisalign attachments: optimized and conventional. Optimized attachments are engineered and patented by Align

Technology to produce exact biomechanical stresses on teeth. When a specific kind and degree of anticipated tooth movement is found, they are automatically inserted by the ClinCheck programme. Conventional attachments are able to be chosen and manually placed by the doctor wherever deemed necessary. These latter attachments aren't specific to Invisalign; they're also employed by other companies or with software to produce in-office aligners using 3-D printers.⁷

Both of these attachments come in various shapes and some maybe more useful than others for specific types of movements. The most common types of conventional attachments include rectangular, rectangular beveled and ellipsoid.⁶

➤ *Configuration of Attachments:*

Various configurations of attachments and their dimensions have been illustrated in different clinical studies.⁵

These are summarized as:

Table 1: Attachment Configurations

S.NO	Configuration	Height	Width	Depth
1.	Ellipsoid	3 mm	2 mm	0.75 or 1 mm
2.	Rectangular	3, 4 or 5 mm	2 mm	0.5 or 1 mm
3.	Rectangular beveled	3, 4 or 5 mm	2 mm	0.25 mm at incisal edge 1.25 mm at gingival margin
4.	Pyramidal	4 mm	3 mm	1.5 mm
5.	Quarter sphere	2.5mm (diameter)	1.5 mm (radius)	1.5 mm (radius)
6.	Vertical ellipsoid	4 mm	2.5 mm	2 mm

A study by Costa et al.⁸ used custom designed composite attachments that were modified from the conventional attachments found that different attachment designs generated significantly different directions and amounts of forces.⁶

Align Technology's "best practice protocols", derived from clinical experience with the Invisalign* system, initially recommended bonded vertical rectangular attachments to control bodily distal movement.⁹

According to a study by Juan Pablo Gomez et al.¹⁰ Optimized Root Control Attachments produced a displacement of model equivalent to typical distal bodily movement.

According to a study by Dasy et al¹¹, Ellipsoid attachments showed no significant effect on retention in the aligner used in this study and beveled rectangular attachments were better suited.

Rectangular attachments are recommended for significant mesio-distal tooth movements and provide a greater surface for force application.¹²

Beveled attachments have the same dimensions as rectangular but are beveled towards the incisal edge or vertically beveled towards the mesial or distal. These attachments aid in extrusion and enhance retention.¹²

Elkholy et al¹³ demonstrated the efficacy of quarter sphere attachments, indicating that quarter sphere attachments and vertical ellipsoid attachments were substantially more efficient in avoiding intrusion while derotation. The quarter-sphere attachment was positioned asymmetrically at the incisal-to-middle-third transition (vertical position) and practically at the mesial-to-middle-third transition (mesiodistally), such that its mesial border touched the longitudinal crown axis, at a 45° angle to the longitudinal tooth axis and a 120° angle to the tooth surface.

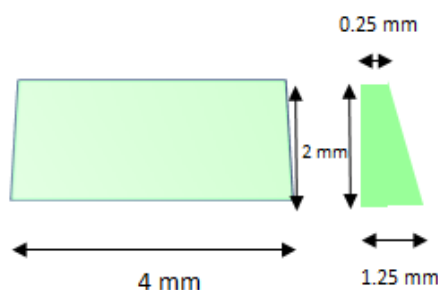


Fig.1: Rectangular beveled attachment

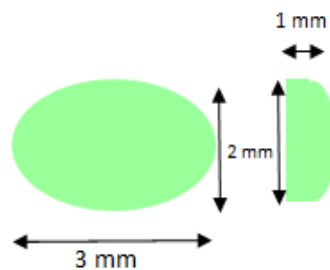


Fig. 2: Ellipsoid attachment

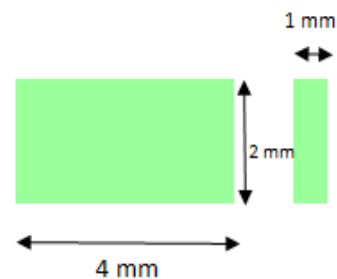


Fig.3: Rectangular attachment

➤ *Efficacy of Attachments:*

FE analysis has shown to be a precise and practical tool in orthodontics for analysing patterns of stress on various tissue structures during bodily motion using

multibracket appliances. It can also help in understanding how composite attachments interact with clear aligners, which can aid in the creation of evidence-based guidelines for such therapy.

A study by Yokoi et al.¹⁴ showed that attachments limited tipping of incisors while diastema closure occurred by bodily movement.

Garino et al.¹⁵ in 2016 established that there was more distal movement of first molars and central incisors where vertical rectangular attachments were placed on five teeth. This asserted that vertical attachments controlled tipping during molar distalization as well as enhanced posterior anchorage.

A FEA study by Savignano et al. confirmed that extrusion of central incisors cannot be achieved without attachments. Also, they emphasized the importance of the shape and position of attachments.¹⁷

An FEM study by Laohachaiaroon et al.⁶ used three attachments namely horizontal rectangular, ellipsoid and rectangular beveled to assess initial displacement and stress distribution of Upper Central Incisor Extrusion with Clear Aligners. The model with horizontal rectangular attachment had the greatest extrusive movement followed by the ellipsoid and then the rectangular bevelled attachment. The study also established that there was palatal tipping as well during extrusion.

Ahmed et al.¹⁶ in 2022 found that the most effective retraction of maxillary incisors was achieved using palatal attachments. The labial attachment model had an advantage of avoiding uncontrolled tipping over palatal placement. The stress distribution was concentrated in the middle third in the labial attachment model while this occurred in the cervical third in the palatal attachment model.

A Comba et al.⁹ research claimed that optimized attachments produced bodily displacement with no uncontrolled tipping of upper canine while distalization using clear aligners. They compared the optimized attachments with vertical rectangular attachments and found that the latter caused uncontrolled crown tipping of upper canine. They also noted intrusion of canine with all models which they counteracted by using Class II elastics with optimised attachments.

➤ *Bonding Protocols:*

After going over the significance of various aligner attachments and the particular movements they perform, it is important to note that their precise bonding. Since every aligner is designed and created using the attachments from the first template, initial bonding discrepancies cause incorrect tooth movements that cannot be fixed by the subsequent aligner during treatment.

A Weckmann et al.¹⁸ research utilised a high and a low viscosity composite via five different protocols to bond attachments. They determined that both the use of the two-phase attachment bonding procedure with high viscous composite as well as the direct procedure with low viscous composite without a perforation in the template reservoir are precise attachment bonding protocols.

In 2019, D'Antò et al.¹⁹ used a flowable, orthodontic and a dental restorative material with varying viscosities to study the influence of composite material type on bonding efficiency of attachments in aligners. The findings of this study showed that the volume and shape of attachments that were replicated using a template on extracted teeth were unaffected by the use of multiple composites with various viscosities.

It should be noted that a stronger force transmission from the aligner to the tooth is linked to increased stress between the aligner and composite attachment with a tooth.²⁰ This makes it essential that correctly built attachments have the highest detachment resistance possible.

III. CONCLUSION

- The use of attachments are undoubtedly an inseparable part of modern clear aligner therapy. They not only improve aligner retention but also increase predictability of various orthodontic tooth movements.
- The configuration of the attachment should be chosen depending upon the type of orthodontic movement required. It gives the impression that rectangular attachments with/without bevel are beneficial for both tooth movement as well as for anchorage.
- Placement of palatal attachments in the anterior teeth is more valuable from an efficacy and aesthetic point of view.
- Use of a low or high viscosity composite and also orthodontic and a dental restorative material are all permissible for aligner attachment fabrication. It may be up to the practitioner to select which of these two methods and composite materials will be employed in the end.

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