

Attachment Types In Aligners For Moderate And Severe Cases

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Abstract:

Background In recent years more and more the aligner treatment is growing on orthodontic field. The modern orthodontic is nowadays trying to extend the limits of using this kind of treatment in more complex cases. One of the greatest challenge is the biomechanic concept in treatment of the rotated teeth and molar distalization to create space. Nevertheless, still seems to be a challenge to clinically achieve the desired success of the treatment. The main focus is in designing different attachment shapes to achieve the desired results and to consider the proper position of attachments.

Materials and Methods This is a systematic research of literature. According to PICO, meaning: Population: clear aligners, Interventions: specific attachment bonding, Comparison: different placement of attachments in specific cases, Outcome: the highest success rate on choosing the correct shape of attachment and retention. Were used and compared different types of studies: in vitro studies, retrospective clinical studies and prospective clinical studies.

Results: includes articles from Pubmed, Scopus and Web of Science.

Grey Literature was also used.

It includes around 20 studies from in vitro and in vivo studies.

Key Word: clear aligners, attachments, positioning

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I. Introduction

The nature of malocclusion is not a disease, but rather a deviation from accepted societal norm that can lead to functional difficulties or concerns about dento-facial appearance for a patient (1)(Brook and Shaw, 1989) Conventionally, fixed appliances were widely used to treat various irregular bites and/or malocclusion. Aligners are manually manufactured and are produced through dental technicians, requiring a lot of time for planned movement of teeth during each orthodontic step (2) As with fixed appliance systems, the term Clear Aligner Therapy (CAT) embraces a wide range of appliances with differing modes of action, methods of construction, and applicability to various malocclusion treatments. All share the use of clear thermoformed plastic aligners that cover many or all of the teeth, but from that common point, there are major and significant differences which affect the ability of any given system to treat a wide range of orthodontic problems.

In 2012, Robert Keim, the editor of the Journal of Clinical Orthodontics nominated two major advances in the previous 15 years in orthodontics, those of temporary anchorage devices and Invisalign. It was further said that: "Invisalign has offered patients a viable alternative to fixed braces" and that "today, practically any malocclusion can be successfully treated using this or similar technologies" (3)

II. Material And Methods

This is a systematic research of literature.

According to PICO, meaning: Population: clear aligners, Interventions: specific attachment bonding, Comparison: different placement of attachments in specific cases, Outcome: the highest success rate on choosing the correct shape of attachment and retention.

Were used and compared different types of studies: in vitro studies, retrospective clinical studies and prospective clinical studies.

Questions according to PICO are: Does the different shape of attachment have an impact in treating moderate or severe malocclusions, from the standard one? Where is the limit of using aligners as a treatment of choice?

III. Results

Search strategy

This study was performed by using study outcomes on free articles on Pub Med, Scopus, Web of Science.

On this study was used published literature and grey literature. Grey literature was searched through OATD (Open Access Theses and Dissertations), while no manual search was conducted.

Data extraction

Data extraction for the study was done independently.

This study includes 20 studies, of which twelve finite element analysis, four in vitro experimental studies and four case control studies

Assesment risk of bias

The risk of bias was thoroughly assessed using RoB 2. As a result, all studies were classified as having a low risk of bias across all domains.

While no significant risk of bias was identified in the included studies, the potential for residual confounding cannot be entirely excluded.

IV. Discussion

The predictability of aligners

The table (Table 1) below (31) has been constructed using a synthesis of reported data from two of the larger aligner manufacturing companies, Align Technology and ClearCorrect. Align Technology is the manufacturer of Invisalign appliances, which have been used to treat the largest number of patients to date (in excess of 18.9 million) of any clear aligner product. ClearCorrect has been used in the treatment of over 80,000 orthodontic cases. (5)

The extrusion of anterior teeth, rotations of rounded teeth and anterior buccolingual inclination improvement are more problematic. (4)

In order to pass the difficulties on achieving the wanted results in moderate and severe cases, the interest on designing different shapes and diameters of the attachments got greater attention.

On the study "Clear aligners in orthodontic treatment", a predictability focus was given in differences in materials and the way of production and in retention strategy. (5)

Nahoum draws a distinction between vacuum-formed and pressure-formed appliances. While both methods use air pressure to form the appliances, vacuum forming involves pressures of 3-14 psi, while pressure forming involved pressures of up to 100psi. Up to a limit, the detail of the inner, fitting surface of the aligner, and hence the intimacy of fit and improved ability to grip and generate forces to a tooth or attachment surface is dependent upon air pressure. Higher pressures therefore tend to equate with improved force generation and higher precision. (6)

Predictable Moderate Severe

Crowding or spacing per arch	Up to 6mm	6-8mm	>8mm
Midline discrepancy	Up to 2mm	2-3mm	>3mm
Central incisor rotation	Up to 40°	40-50°	>50°
Lateral incisor rotation	Up to 30°	30-40°	>40°
Canine and premolar rotation	Up to 45°	45-55°	>55°
Molar rotation	Up to 20°	20-30°	>30°
Anterior extrusion per arch	Up to 2.5mm	2.5-3mm	>3mm
Anterior intrusion per arch	Up to 0.5mm	0.5-1mm	>1mm
Posterior intrusion per arch	Up to 0.5mm	0.5-1mm	>1mm
Posterior extrusion per arch	0mm	0.5mm	>0.5mm
Expansion per quadrant	Up to 2mm	2-3mm	>3mm
Anteroposterior correction	Up to 2mm	2-4mm	>4mm
Incisor lingual root torque	0-10°	10-15°	>15°
Posterior tooth lingual root torque	0-5°	5-10°	>10°
Posterior tooth distal movement (maxilla)	0-2mm	2-4mm	>4mm
Posterior tooth mesial movement	0-1mm	1-2mm	>2mm

Some aligner systems involve tooth and gingival coverage (Clear Correct, K-line, Originator, Prestige) and it is claimed that this provides superior appliance retention. (7)

Some of the aligners have no attachments, while recently the presence of the attachments plays greater role in having better results.

Durrets (8) findings show that extrusion and intrusion is much better treated with the presence of attachments, considering no different results in the change of the shape of the attachments.

Clear aligners also differ from traditional braces in their ability to exert pull force, which allows for more predictable movements of the teeth (9) (10)

The biologic force generated by the clear aligner is the key to its success, as it is designed to pre-activate its attachment interface with a specific tooth and then optimized attachment form morphology to exert a desirable orthodontic force for moving it in a specified direction. Overall, however, it is important to note that the nature of the underlying forces needed to correct and align—that is, “straighten out”—teeth is complex and multi-faceted. (11). (12)

Intrusion

On a study performed in 189 intruded teeth (13), the study has shown that the highest rate of intrusion is seen in maxillary central incisor (45%) and mandibular lower incisor (47%). The lowest rate was seen in lateral incisor, only 33%.

The rate of intrusion that was intended was 0.72mm

Extrusion

The extrusion was less predictable and has a lower rate of success and predictability.

Krieger E, Seiferth J, Marinello I, et al. (14) on their study “Invisalign® treatment in the anterior region: were the predicted tooth movements achieved.”, came to a conclusion that the deviations on the vertical plane were big. Approximately -0.71 mm from standard deviation 0.81mm.

The study “A prospective clinical study evaluating the efficacy of tooth movement with Invisalign” (13) the results had shown that the maxillary (18 %) and mandibular (25%) central incisors had the lowest success rate in extrusion. The average amount of extrusion attempted was 0.56 mm.

Rotation

A prospective study reported that the canine has the highest mean accuracy and lowest standard deviation when the IPR is used (43%. SD=22.6%) (15)

For rotations greater than 15° the accuracy of maxillary canine movement was significantly reduced (19%; SD = 14.1%; $P < .05$). (13)

The study “. Treatment outcome and efficacy of an aligner technique—regarding incisor torque, premolar derotation and molar distalization” reported that the efficiency of derotation using aligners technique depends on the level of rotation: for premolar rotations with a staging of <1.5°/aligner, the total efficacy was 41.8% (SD = 0.3%), whereas with a staging of >1.5°/aligner, the accuracy decreased to 23% (SD = 0.2%).

In general, derotation of central upper incisor showed greater success rate(55%), lower central incisor (52 %), comparing to upper canine (32%) and lower canine (29%). (13)

Mesio-distal tipping

Djeu G, Shelton C, Maganzini A (17) study showed very similar results of root angulation in the end of treatment of similar orthodontic cases, treated with Clear Aligners and braces.

Drake (18) reported that 4.4 times more orthodontic tooth movement occurred during the first week than during the second week of aligner wear, considering all of the 2-week periods.

Kravitz et al. (13) study showed a mean accuracy of 41% for mesio-distal tipping, in which the highest accuracy was achieved by the maxillary (43%) and mandibular (49%) lateral incisors.

The maxillary (35%) and mandibular (27%) canines and the maxillary central incisors (39%) had the lowest accuracy.

Buccolingual tipping

In general studies show that there are better results achieved via fixed orthodontic appliances.

Kravitz et al. (13) showed that lingual crown tip (53%) was significantly more accurate than labial crown tip (38%), particularly for maxillary incisors.

Djeu (19) study showed much better results on buccolingual tipping by using fixed orthodontic than CAT.

The importance of the placement of attachments

Attachments are bonded to the teeth to improve aligner retention and tooth movement, but clinically seems to be a challenge to plan and achieve the desired result on moderate and severe cases.

Below will be discussed specific researches from different authors.

The influence of attachment positioning on movement efficiency (incisors intrusion/retrusion) and stress distribution

This study done by Ahmed et al. (2022) (20), with the study “The influence of attachment positioning on movement efficiency (incisors intrusion/retrusion) and stress distribution”

On his study the author analyzed movements of the tooth by using attachments:

1. Model without attachments
2. Model with labial attachments
3. Model with palatal attachments
4. Model with labial and palatal attachments

The most retrusion effect was achieved with palatal attachments.

Attachments on labial surface, the stress distribution was concentrated on middle third.

The attachments on labial surface prevented uncontrolled tipping.

The influence of attachment positioning on movement efficiency (molar intrusion)

This study done by Fan et al. (2022) (21) came to a conclusion that the best molar intrusion is achieved by placing attachments on buccal and lingual surfaces. This avoided tipping.

The influence of attachment shape on movement efficiency (molar distalization)

Ayidaga et al. 2021 (23) studied the molar distalization. The no attachment model shows undesired tipping of the molar and the result weren't fulfilling. Meanwhile models with rectangular attachments showed good result of tooth movement on Y-axis. The best results and stress distribution was achieved with guided attachment positioned on the buccal surface of maxillary first molar. The tipping percentage was the lowest.

The influence of attachment use on movement efficiency and stress distribution (maxillary second molar distalization)

Rossini et al. (2020) (22) studied the distalization of secondary molar by placing attachment from canine to first molar and from canine to second molar.

The attachments were placed vertically and were rectangular.

The best results were achieved by including attachments on second molar.

Incisor extrusion using aligners

Rossini et al (2021) (26), on his study analyzed:

1. Model without attachment
2. Horizontal rectangular attachment only on incisors
3. Rectangular attachment from the second molar to canine
4. Rectangular attachments from the second molar to the canine used together with optimized extrusion attachments on incisors
5. Rectangular attachments from the second molar to the canine used together with rectangular buccal horizontal attachments on the incisors
6. Rectangular attachments from the second molar to the canine used together with rectangular palatal horizontal attachments on the incisors

The best result was achieved with the presence of 3mm rectangular horizontal attachments on the buccal or palatal surface of the upper incisors with additional rectangular vertical attachments in the lateral from the canine to second molar, seemed to produce the most efficient force system to extrude incisors with minimal aligner deformation. The presence of attachments on posterior teeth provided better anchorage.

For incisor extrusion, another study was done by Laohachaiaroon et al. (2022) (24). On his study, he analyzed these models:

1. Without any composite attachment
2. Rectangular beveled attachment on labial surface of the central and lateral incisors
3. Ellipsoid attachment on the labial surface of the central and lateral incisors
4. Horizontal rectangular attachment on the central and lateral incisor

The greatest extrusive effect had the model with horizontal rectangular attachment, around 0.037991 mm.

The model with the ellipsoid attachment had extrusion around 0.037606 mm and the model with rectangular beveled attachment had 0.036786 mm extrusive effect.

Meanwhile, the model with no attachment showed no significant improvement (0.000105 mm)

Saviagnano et al. (2019) (25), on his study “The influence of attachments on movement efficiency and stress distribution during upper incisor extrusion”, analyzed:

1. Models without attachments
2. Models with horizontal rectangular palatal attachment
3. Models with horizontal rectangular buccal attachment
4. Models with ellipsoid buccal attachment

The results were: there was no clear difference between the rectangular and ellipsoid attachments. The position of the attachment showed a stronger influence on the outcome compared to the shape (palatal instead of buccal). The extrusion of an upper central incisor cannot be achieved without any attachment.

Canine derotation using aligners

Kravitz et al. (2008), (30) on a study of:

1. Models with no attachments
2. Models with no attachments and IPR
3. With attachments only

Considered that ellipsoid, vertical attachment and IPR don't significantly improve canine rotation using aligners.

On general discussion, about rotations particularly, in 2014 Simon et al. (27) described that with the support of an attachment, accuracy increased from 42.4 to 47.3%, however another study concluded that the accuracies of all teeth in upper and lower arch were higher. (28)

On another study, it has been further suggested that attachments can enhance the effectiveness of derotation movement and improve retention by using undercuts. (32-34)

According to literature, round teeth (canines, first premolar and second premolars), because of their conical shape, are the less predictable to achieve their result in rotation. (29)

V. Conclusion

According to the studies, orthodontic movements using aligners is much more accurate by using attachments. Evidence indicates that combining attachments on both buccal and lingual surfaces of the tooth will be more effective for rotating rather than using attachments only on one surface, although evidence shows that it could cause stress on periodontium.

Using rectangular or ellipsoid attachments doesn't significantly give great differences, but for a small percentage rectangular ones are more effective.

Retention and effectiveness is improved by using undercuts on aligners.

The presence of attachments gives more anchorage, when they are present on posterior teeth, and if possible should always be included on second molar as well.

For extrusion and rotation is very recommended the presence of attachments.

More prospective studies are still needed to evaluate better outcomes and retention for using aligners

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