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Influence of attachments on the efficiency of molar distalization using clear aligners – An updated systematic review

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ABSTRACT

Background: With the advent of intra oral scanning, virtual treatment planning and 3D printing, the field of orthodontics has grown beyond limits. With increasing demand for invisible orthodontic treatment, clear aligners have set a mark in providing efficient orthodontic tooth movements. Several clinical studies have been published, especially in the last decade to justify the same. Efficiency of various tooth movements with clear aligners has also been extensively studied. One of the most challenging tooth movements with clear aligners is molar distalization. The distalization for maxillary molars is needed to correct non extraction patterned class 2 malocclusions. Several studies have extensively studied the same however a sound clinical judgment is required on the basis of high level of evidence.

Objective: The objective of this systematic review was to systematically search the literature and assess the available evidence regarding the effectiveness of clear aligners in bringing about molar distalization with or without attachments.

Search Strategy: An electronic database search of published and unpublished literature in english was performed till April 2021 in the following databases: Google scholar, PUBMED,TRIP, LILAC, Web of science and Cochrane databases. The reference list of all the eligible articles were examined for additional studies. Articles were selected based on selection criteria. Reporting of this review was based on the Preferred reporting items for systematic review and meta-analysis (PRISMA) guidelines.

Selection Criteria: All prospective/retrospective clinical studies on subjects/patients treated with clear aligners to achieve molar distalization with or without attachments were included in this Systematic Review.

Data Collection And Analysis: Data extraction from the included articles was done by the authors independently.

Data characteristics were extracted using data collection forms whereas the quality of the study was assessed using the Cochrane Risk of bias tool for randomized control trials and NewCastle Ottawa scale for non randomized control trials.

Results: A total of 5 articles were included in this review. The amount of molar distalization reported was 2- 3mm.

Conclusion: Of the five studies included, all the studies reported significant amounts of distalization. 3 retrospective studies concluded that distalization with aligners is the most effective of all tooth movements. One study concluded that aligners effectively achieved distalization of 2-3mm with efficacy of 87%, two other studies concluded that aligners effectively distalized the molars when tooth movement was performed using attachments, with good control over vertical dimension, and mesio-distal tipping.

Keywords: *Aligner technology, Clear aligners, Clinical efficiency, Invisible orthodontics, Molar distalization.*

INTRODUCTION

With increased demand especially by adult patients for esthetic alternatives to conventional fixed appliances, Clear aligner therapy has been the one to meet these needs [1–3]. Clear aligner therapy has become well-known across the world as an attractive alternative to labial fixed appliances [4]. This world wide famous appliance has evolved over the years in terms of technology, aligner material used and also in ways of improving treatment efficiency [4–6]. As a result, the clear aligner system needs to be improvised continually in all aspects. One such important aspect are the Auxiliaries used in clear aligner therapy[7–9]. Attachments form the most crucial part during planning and sequencing of aligners as these act as force transducers required to bring about the desired tooth movement. They prove to be important inorder to improve the efficiency of clinical treatment with aligner therapy[9]. Literature published previously has elaborated widely on the efficiency of tooth movements such as molar distalization, premolar derotation, incisor inclination and angulation etc achieved with aligners [8–12]. Studies have also been conducted to understand subjective outcomes such as quality of life, pain perception etc [13–16]. More technically, research has also been conducted to study which type, shape and size of attachment is essentially beneficial in bringing about the desired tooth movement. But more scientific evidence and data is needed to make a clinical judgment especially in terms of molar distalization as it seems to be a challenging tooth movement to be produced with aligners. The present systematic review aims at evaluating the efficiency of molar distalization with and without attachments in clear aligner therapy.

MATERIALS AND METHODS

The present systematic review was registered in the PROSPERO database (CRD42021250071) during the initial stages of review after a primary search was carried out in PUBMED.

This systematic review was structured according to the Cochrane Handbook for Systematic Reviews of Interventions 2nd edition [17] and the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta analysis [17,18]

Eligibility Criteria

With reference to the PICOS of the current systematic review, the inclusion and exclusion criteria were employed. Regarding the “population”, patients with Angle’s class 2 malocclusion who needed maxillary molar distalization and were treated with clear aligners were selected. The “ Intervention” was distalization of molars done using attachments. The “ comparison” group included cases in which molar distalization was done without attachments. The primary outcome of interest was efficiency of clear aligners in producing Molar distalization using attachments and the secondary outcome was to evaluate the Influence of molar distalization on the vertical heights of

the face and Influence of attachments and type of attachment on the amount of molar distalization. All included studies were Randomized control trials (RCT's), prospective and retrospective cohort studies (CCT's), and in vitro model studies written in English language only.

Search Strategy

The electronic search was carried out by the principal investigating author on databases Google Scholar, PUBMED, TRIP, LILAC, Web of science and Cochrane database for all studies published from 1 January 1990 to 31st April 2021. The keywords used and details of search strategy are given in Table 1. Reference lists of selected articles were hand searched inorder to find any other relevant article that did not appear during electronic search.

Study Selection And Data Extraction

Two reviewers had independently carried out the study selection protocol according to the eligibility criteria and the third author resolved disagreements if any existed. An initial screening of title and abstract was carried out. Following which full text of the article was read and the study was selected if all components met the inclusion criteria. The data extracted from each study are general details of the study (author name, year of publication), study design, groups and sample size, mean age of treated patients, intervention (with/ without attachments), treatment duration and time and outcomes evaluated.

Assessment Of Risk Of Bias

The quality of the included studies was evaluated by two reviewers and if a lack of consistency was observed, the third author arrived at a conclusion. The cochrane risk of bias tool was used for RCTs and was evaluated on the basis of five domains (selection, performance, attrition, reporting and other)[19]. The overall risk of bias was evaluated as high, low or unclear. A study was considered to have low risk of bias if all fields were assessed as at low risk of bias. A study was considered to have unclear risk of bias if one or more fields were assessed as at unclear risk of bias. A study was considered high risk when one or more fields were assessed as at high risk of bias. Newcastle - Ottawa Quality Assessment Scale was used for assessing the quality of cohort studies. The studies were assessed based on selection of participants, comparability, and outcome [20].

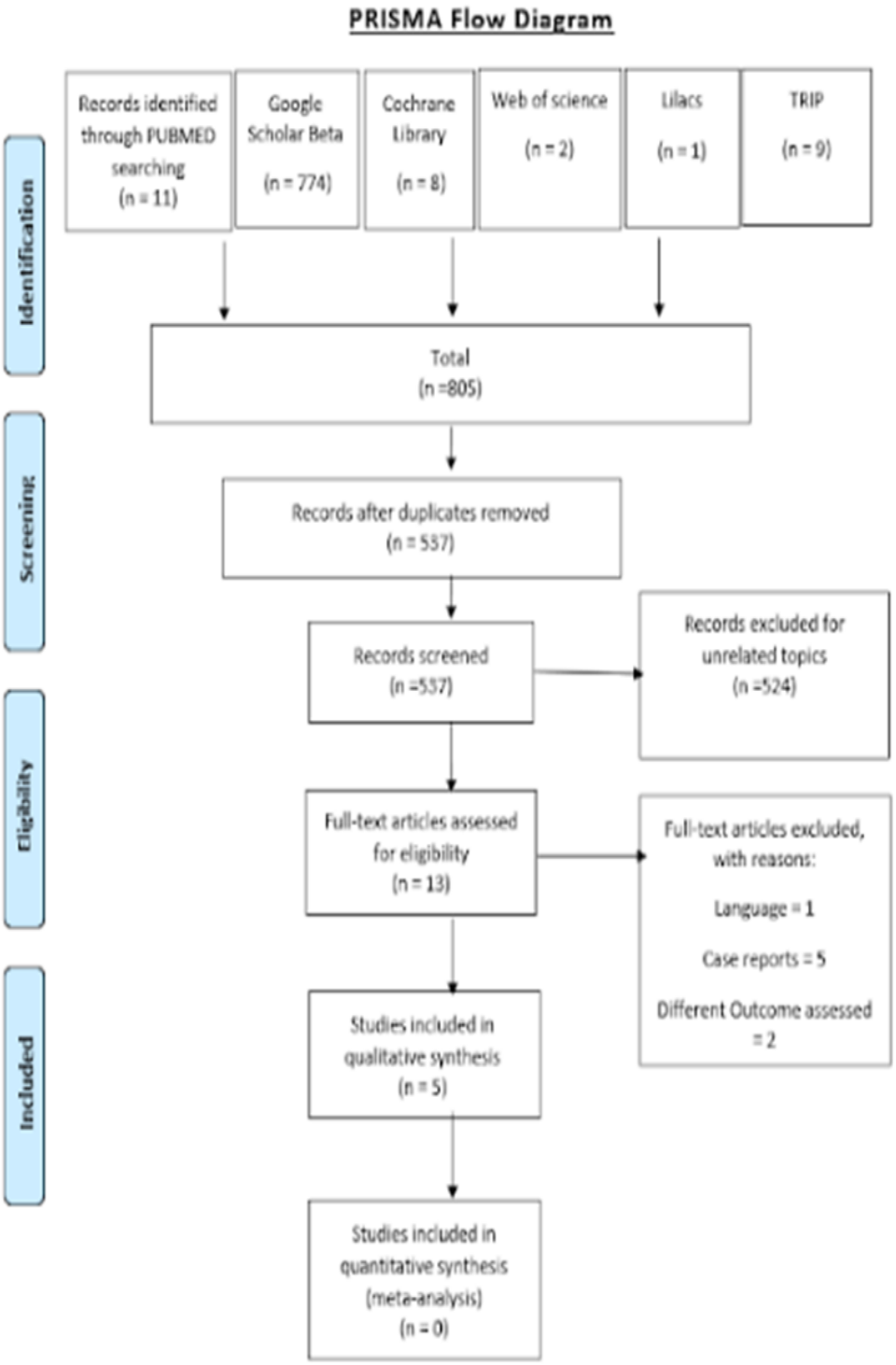
Assessment Of Risk Of Bias Across Studies And Assessment Of Level Of Evidence

The (GRADE) grading of recommendations assessment, development and evaluation approach: high certainty, moderate certainty, low certainty and very low certainty was used to evaluate the certainty of the evidence[21].

RESULTS

Search Strategy

Google Scholar, PUBMED, TRIP, LILAC, Web of science and Cochrane databases were searched and a total of 805 articles were retrieved. 537 Duplicate articles were removed and the remaining were assessed based on the inclusion criteria set. A total of 13 articles full text was evaluated out of which 5 were finally included in the systematic review for Qualitative analysis. The PRISMA flowchart is shown in Figure 1.



Characteristics Of Included Studies

The characteristics of the studies included are tabulated in Table 1.

TABLE 1: Shows the characteristics of the individual studies.

Author	Study group	Study design	Sample size	Average age	Inclusion criteria	Method of assessment	Outcome assessed	Result	Conclusion
Simon et al 2014 ([9,22]	Patients treated with Invisalign	Retrospective clinical study	30 patients	32.9 ± 16.3 years	Patients treated using Invisalign.	Pre-treatment and final plaster cast models were laser-scanned, and the achieved tooth movement was determined by way of a surface/surface matching algorithm. The results were compared with the amount of tooth movement predicted by ClinCheck®.	Amount of molar distalization with and without attachments, Accuracy of incisor torque and premolar derotation.	Distalization of an upper molar was the most effective movement, with efficacy approximately 87% (SD = 0.2). 2.6mm movement with CA	Molar distalization can be performed using Invisalign aligners with attachments.
Ravera et al 2016 [9]	Patients treated with Invisalign	Multicentre retrospective clinical study	20 Patients	29.73 ± 6.89	Patients undergoing Invisalign therapy.	Lateral Cephalograms at: T0= Pre-Treatment T1=Post - Treatment	Linear Measurements : 17mcPtv	At the post-treatment point, the first molar moved distally 2.25 mm without significant tipping (P = 0.27) and vertical movements (P = 0.43). The second molar distalization was 2.52 mm without significant tipping (P = 0.056) and vertical	Aligner therapy with attachments can distalize 1st molars by 2.25mm without significant tipping or vertical movement of the crown. No changes in facial heights were revealed.

								movements (P = 0.25).	
Garino et al 2016 [23]	Patients undergoing Invisalign therapy	Randomized control trial	30 patients (18 females, 12 males)	30.5 years	Patients undergoing Invisalign therapy.	Pre and post treatment lateral cephalograms were taken	Linear measurements: 17mcPtv , 17ccPtv, 16mcPtv, 16ccPtv	Distalization of 2nd molar: From mesial cusp – 2.30mm, From centre of crown – 1.71mm. Distalization of 1st molar: From centre of crown- 2.13mm	With vertical rectangular attachments, 2mm of 1st and 2nd molar distalization can be achieved.
Caruso et al 2019 [24]	Patients treated with Invisalign	Retrospective clinical trial	10 patients (8 females, 2 males)	22.7±5.3 years	Patients treated with Invisalign	Pre and post treatment lateral cephalograms were taken	SNA, SNB, ANB, SN^GoGn, SN^Fop, SN^PP, 16-PP(mm), 16^PP, 17-PP(mm), 17^PP, 11^PP, S-Go (mm), N-Me (mm), S-Go/N-Me	1st molar distalization of 2mm observed which was statistically significant, 2nd molar distalization of 3mm observed which was statistically significant, Mean variation in SN-GoGn= 0.1±2.0 degrees, statistically non significant.	Upper molar distalization with orthodontic clear aligners was observed, Upper molar distalization allows good control of vertical dimension.
Rossini et al 2020 [25]	Patients undergoing Invisalign treatment	Prospective clinical study	Not mentioned	Not mentioned	Patients treated with Invisalign	FEM analysis	Tooth displacement with attachment in mm	Distalization of the 1st molar was 0.03mm Distalization of the 2nd molar was 0.02mm with attachment.	Distalization can be brought about by using vertical attachments. In the present study the amount of distalization was negligible.

Risk Of Bias Of Individual Studies And Across Studies

Figure 2 and Table 2 shows the risk of bias of the individual studies. Only one RCT was included in this systematic review and was assessed as High risk of bias. According to the risk of bias evaluation of non randomized control trials using Newcastle Ottawa scale, of the 4 studies included, 3 showed a moderate risk of bias and 1 study showed a low risk of bias.a333

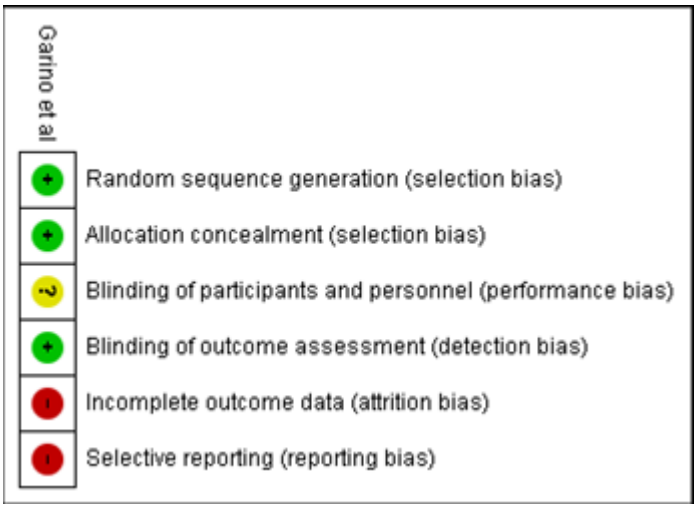


FIG 2: Risk Of Bias Assessment Using Revman 5.4 For Randomized Control Trial.

TABLE 2: Quality Assessment of Included Studies Using Newcastle - Ottawa Quality Assessment Scale For Cohort Studies:

S.No	Study	Selection	Comparability	Outcome	Overall
1	Simon et al 2014	***	**	***	good
2	Ravera et al 2016	**	**	***	moderate
3	Caruso et al 2019	**	**	***	moderate
4	Rossini et al 2020	**	**	***	moderate

DISCUSSION

Three retrospective studies, one randomized control trial and one prospective research were considered in this systematic review. According to the findings and interpretations of these papers, clear aligners promote successful molar distalization with attachments in class II patients with permanent dentition. Furthermore, clear aligners have demonstrated great control of the vertical dimension, as well as excellent control of the incisal torque without anchoring loss during the orthodontic operation.

Caruso et al 2019 's study sought to investigate the impact of consecutive molar distalization on vertical dentoskeletal dimensions [24]. This retrospective study revealed that upper molar distalization with orthodontic aligners ensures good vertical dimension control, making it an effective treatment option for hyperdivergent or open bite individuals. It also enables for great regulation of incisal torque without anchor loss throughout the orthodontic treatment. The goal of the current systematic review and the study by Caruso et al suggested that a significant distal movement of the upper molars (and the related correction in molar relationship) with absence of distal tipping, confirming the efficiency of clear aligners in upper molars' distal body movement while controlling the vertical dimensions [24].

Another retrospective research published in 2016 by Ravera et al. was predicated on the notion that aligners cannot promote molar distalization. The discovered results, however, were contrary to the null hypothesis. According to the findings,

Invisalign aligners are successful in distalizing maxillary molars in non-growing patients without considerable vertical and mesio-distal tilting motions[9,22].

Simon et al, 2014 ([9,22] examined 30 patients' lateral cephalograms in a retrospective analysis. One of the following tooth movements was performed on all patients: (1) Incisor torque more than 10°, (2) Premolar derotation greater than 10° (3) Molar distalization more than 1.5 mm. The groups (1)-(3) were subdivided as follows: in the first subgroup (a), the movements were supported by an attachment, whereas in the second subgroup (b), no auxiliaries were utilized (except incisor torque, in which Power Ridges were used). All tooth movements were carried out in a split-mouth arrangement. To assess clinical effectiveness, pretreatment and final plaster cast models were laser scanned and tooth movement was calculated using a surface/surface matching method. ClinCheck® predicted the amount of tooth movement, therefore the outcomes were compared. The total mean effectiveness was 59 % (standard deviation = 0.2). Upper incisor torque accuracy was 42 % on average (SD = 0.2). Premolar derotation had the lowest accuracy, at around 40% (SD = 0.3). The most successful movement was distalization of an upper molar, with an efficiency of around 87 % (SD = 0.2) ([9,22] .

The lateral cephalograms of 30 non-growing Invisalign individuals were evaluated in a randomized control research conducted by Garino et al, 2016 [23]. The study concluded that when vertical attachments were placed on all 5 distalized teeth in people treated with Invisalign, the upper 1st and 2nd molars were each distalized around 2mm [23].

A finite element analysis was performed in another research by Rossin et al, 2020, to examine stress created on the aligner, equivalent stress on the PDL, tooth displacement pattern, and aligner deformation [25]. Three experimental models were created: one with no attachment, one with 3mm of vertical attachment from canine to first molar (ATT 3-6), and one with 3mm of vertical attachment from canine to second molar (ATT 3-6). (ATT 3-7). The author noticed more movement of the upper 2nd molar with ATT 3-6 (0.036mm) in the distal direction, compared to no ATT and ATT 3-6, which moved by 0.02mm and 0.021mm, respectively. The author found that attachments are required for a 2nd molar's physical movement, and these attachments reinforce anchoring to operate as active units during distalization. 3-7 attachment position appears to be promising for successful molar distalization [25].

Previous research on distalization in class II instances found that several orthodontic equipment had unfavorable impacts on the upper molar distalization method and the sagittal vertical pattern, such as clockwise rotation of the mandibular plane and an increase in anterior face height [26–29].

Distalizing tools such as the Distal Jet, Pendulum Appliance, and Jones Jig Unwanted motions such as distal tipping of first molars, proclination of maxillary incisors, increased mandibular plane angle, and decreased facial height occur during the distalization process [30–34]. TADs and IZCs, which are skeletally attached devices, have recently become a popular choice for distalization.

The disto-palatal rotation of first molars and a modest protrusion of anteriors have been documented in the literature. The mandibular plane angle and anterior facial height, on the other hand, remain unaltered. Shahani et al. found that aligners provide superior overall control of distalization than Infra-Zygomatic Screws in a recent paper comparing distalization accomplished by transparent aligners and Infra-Zygomatic Screws.

For the reasons stated above, molar distalization is not recommended for hyperdivergent individuals. This warning is based on the notion that when maxillary molars are distalized within the occlusion's wedge, they will prop open the bite. This action, when accompanied with a rearward movement of the mandible, is thought to augment the vertical dimension, particularly at high angles. When planning molar distalization, it is critical to examine the patient's vertical development pattern. Premature contacts may promote a clockwise rotation of the jaw, worsening the profile and causing bite opening. In our investigation, distal movement was not

linked with tooth extrusion or incursion movements. However, the thickness of the aligners and the resulting biting block effect might account for the lack of change in anterior vertical dimension. The current comprehensive study, on the other hand, demonstrates that effective molar distalization may be accomplished using clear aligners, with efficacy and without jeopardizing vertical dimension, anchor loss, or upper molar tipping. As a result, orthodontic aligners may be a viable option for upper molar distalization, particularly in hyperdivergent or open mouth individuals, at least for distal molar movements of 2–3 mm.

Strength And Limitations Of The Study

The PRISMA guidelines were used to conduct this systematic review. Various combinations of search phrases were used to search electronic databases. This analysis examined all possibly qualifying research up to April 2021. The authors separately performed article screening, data extraction, assessment of study characteristics, risk of bias, and assessment of level of evidence, all of which were merged. All quality assessments were conducted in accordance with the applicable universal requirements. Any issues that arose were handled via conversation. Every attempt was made to decrease the amount of prejudice in the review. The number of research published on this issue is few, and the evidence they provide is moderate to poor. This affects the interpretation and conclusions of the systematic review. As a result, there is a need for more research into higher characteristics and the elimination of confounders in this subject. Although the findings are encouraging, further research on this area is needed, including randomized clinical trials and a bigger sample size. In comparison to prospective research, retrospective studies have some drawbacks. Selection bias and misclassification or information bias as a result of the retrospective component are two biases that might have a detrimental influence on the authenticity of this sort of study. However, due to the difficulty in achieving an appropriate sample size, conducting prospective research assessing the consequences of a rare therapeutic treatment is rather challenging.

Implication For Future Research

- RCT with a larger sample.
- Prospective studies with a similar control group.
- Studies to produce distalization more than 2-3mm.

Implications For Practice

This review's clinical implications suggest that clear aligners with attachments on 3-7 can be used as the appliance of choice for molar distalization of 2-3mm, particularly in hyper divergent or open bite cases where the distalization can worsen the bite and cause the mandible to auto-rotate backwards and downwards.

CONCLUSION

The purpose of this systematic study was to focus on the role of clear aligner attachments in inducing molar distalization movement in non-extraction class II patients. According to the current literature, clear aligners can be utilized as a preferred device for distalizing upper molars by 2-3 mm in order to achieve a class I molar relationship with attachments positioned from canine to 2nd molar. Clear aligner therapy physically pushes teeth distally and gives you good control over mesio-distal crown tilting and vertical occlusion.

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CONFLICT OF INTEREST

No conflict of interest.

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