



COMPARATIVE EVALUATION OF TREATMENT OUTCOMES OF ALIGNERS AND FIXED MECHANOTHERAPY: A META-ANALYSIS

Dr. Unnati D. Parekh^{1*}, Dr. Shraddha Shetti¹, Dr. Jiwan Asha Agrawal²,
Dr. Manish Agrawal³, Dr. Lalita Nanjannawar⁴, Dr. Sangamesh Fulari⁵

Article History: Received: 25.03.2023

Revised: 07.05.2023

Accepted: 21.06.2023

Abstract

Aim: The aim is to systematically review existing evidence from patient records who underwent orthodontic treatment and to compare whether there is a difference in treatment outcome with aligners to fixed mechanotherapy for comprehensive orthodontic treatment.

Methods: PRISMA guidelines were used, and PROSPERO (CRD42022365558) registration was done. Four electronic databases (Pubmed, Medline, Scopus and Google Scholar) were searched up to 2020. There were no restrictions on year and publication status. Randomized clinical trials (RCTs) and Cohort study comparing treatment outcomes with aligners and with Fixed mechanotherapy using ABO-OGS parameters were included. Risk of bias was done by Cochrane risk of bias (ROB) -2 and graph was plotted using RevMan software version 5.3. The standardized mean difference (SDM) was used for an overall pooled estimate.

Results: Out of initially identified 2277 searches, twelve studies were included in review. Four studies were included for meta-analysis. Based on standard mean difference for objective grading system (OGS) and discrepancy index (DI) the treatment outcome is more favourable for fixed mechanotherapy, and difference is statistically significant ($p > 0.05$). Though the appointment and repair are less for aligners the stability of treatment is satisfactory for fixed mechanotherapy.

Conclusions: Treatment outcomes are better in fixed mechanotherapy as compared to clear aligners. ABO DI showed results in favour of aligners in parameters like crowding, buccal posterior crossbites and cephalometric. Whereas majority of parameters favoured ABO OGS score in favour of fixed mechanotherapy except for overjet. However, the treatment duration is more or less same in both the appliances.

Clinical Significance: Aligner system has revolutionised dentistry thus the present meta-analysis will aid in selection of orthodontic care delivery system for the patients seeking orthodontic treatment.

Keywords: Aligners, Discrepancy Index, Fixed mechanotherapy, Objective Grading System

^{1*}Postgraduate student, Department of Orthodontics and Dentofacial Orthopaedics, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Sangli Maharashtra, India

¹Associate Professor, Department of Orthodontics and Dentofacial Orthopaedics Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Sangli Maharashtra.

²Professor and Head of Department, Department of Orthodontics and Dentofacial Orthopaedics, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Sangli Maharashtra, India

³Professor, Department of Orthodontics and Dentofacial Orthopaedics, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Sangli Maharashtra, India

⁴Associate Professor, Department of Orthodontics and Dentofacial Orthopaedics, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Sangli Maharashtra, India

⁵Associate Professor, Department of Orthodontics and Dentofacial Orthopaedics, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Sangli Maharashtra, India

*Corresponding Author:

Dr. Unnati D. Parekh^{1*}

^{1*}Postgraduate student, Department of Orthodontics and Dentofacial Orthopaedics, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Sangli Maharashtra, India

Email: ^{1*}unnatiparekh16@gmail.com

DOI: 10.31838/ecb/2023.12.s3.523

1. Introduction

The extensive use of technology in recent years has revolutionised all the fields including medicine and dentistry. Aesthetic has been the prime concern for the patients as there is a steady increase in more adults pursuing orthodontic treatment. Recently aligners have become a choice of treatment alternative to fixed orthodontic treatment. Many manufacturers have been promoting aligners with good marketing advertisement and more adult patients are opting for this alternative and are unaware about the actual mechanics. However, the appliance indicated for the patient is dependent on the clinician based on the malocclusion present.

Orthodontic treatment ensures the proper alignment of the teeth and improves the occlusal and jaw relationship. This not only aids in better mastication, speech, and facial aesthetics, but also contributes to general and oral health, thereby improving the quality of life. Thus, the demand for orthodontic treatment has increased in both adult and young patients. Multibracket appliances are the most common and traditional treatment method used in contemporary orthodontics.

The concept of clear aligners was derived from concept of “the positioner to refine the final stages of orthodontic treatment” given by Kesling in 1940.¹ Inspired by this in 1971 Ponitz introduced “the invisible retainer”.² These appliances have continuously evolved over years to achieve tooth alignment and stable occlusion. Many manufacturers have been promoting aligners with good marketing advertisement and more adult patients are opting for this alternative. However, the appliance indicated for the patient is dependent on the clinician based on the malocclusion present.

The fundamental concepts of modern clear aligner therapy can be traced back to Herald Dean Kesling in 1945. The desire for this type of treatment was driven by Kesling’s vision of a simple appliance that would guide the movement of all teeth into their ideal positions with relation to one another, without the interferences from any traditional bands or wires. This led to the conception of a device known as the “Tooth Positioning Appliance”. It is an active orthodontic appliance used for final artistic positioning of teeth as well as serving as an effective retainer. As a finishing appliance, the positioner took advantage of the fact that most teeth are still unstable and mobile from the on-going treatment and should respond readily to its influence.

Contrary to many medical fields, it is common in orthodontics that novel marketed products and treatment approaches are clinically adopted based on advertisement policies, apparently without the appropriate clinical evidence claimed by the manufacturers. It is essential that alternative treatment methods offered to orthodontic patients are based on both the doctor’s clinical expertise and strong clinical evidence. Ideally, treatment decisions should be based on well-designed and -reported comparative clinical trials on human patients after meticulous considerations of treatment efficacy and adverse effects.

The data available is inadequate to evaluate the amount of discrepancy between predicted and actual achieved movements with aligners, and almost no data about post treatment stability, unlike for fixed orthodontic treatment. In past years, few studies were carried out to check the efficacy of aligners with fixed mechanotherapy, however there are diverse results for the same.

Therefore, the aim was to systematically review existing evidence from patient records who underwent orthodontic treatment and to compare whether there is a difference in treatment outcome with aligners to fixed mechanotherapy for comprehensive orthodontic treatment. Till date, no study has provided a comparison of aligners with fixed mechanotherapy with success as an outcome. Based on which best treatment option could be established. Therefore, we updated our research for related articles and conducted a systematic review with the aim to compare aligners with fixed mechanotherapy in patients. The purpose of this study was to aid in comparative evaluation of treatment outcomes of aligners and fixed orthodontic mechanotherapy using ABO-OGS scoring system.

2. Methods

Protocol development

PRISMA³ guidelines were used, and PROSPERO (CRD42022365558) registration was done.

Study design

Participants (P), Intervention (I), Comparison and Outcome (O) format was proposed⁴

P (Participants) – Patients underwent treatment either with aligners or fixed appliances (fixed mechanotherapy)

I (Intervention) – Patients underwent treatment with aligners

C (Comparison) – Patients underwent treatment with fixed appliances (fixed mechanotherapy)

O (Outcome) – success of the treatment achieved

Eligibility Criteria

The studies included were articles in English language, having sufficient data on aligners and fixed appliances (fixed

mechanotherapy) with success as an outcome, studies published between 2000 – 2021 and having relevant data on aligners and fixed mechanotherapy with success as an outcome, randomized controlled trials, comparative studies, articles from open access journals and articles reporting the study outcomes in terms of mean and standard deviation. The Excluded articles were the studies conducted before year 2000, articles in other than English language, reviews, abstracts, letter to the editor, editorials, articles not from open access journals, articles not reporting the study outcomes in terms of mean and standard deviation, articles not comparing aligners and fixed appliances (fixed mechanotherapy) and reporting success as an outcome.

Data Extraction

Descriptive study data was extracted with the following headings: author(s), country of study, year of study, study design, treatment characteristics, appliance used, follow up period and outcome detail.

Search Strategy

A search was performed for the studies published within the last 21 years using the following databases: PubMed, google scholar to retrieve articles in the English language from 2000 to 2021. A manual search of all the journals of orthodontics and dentofacial orthopaedics was carried out which included the Dental press journal of orthodontics, American Journal of Orthodontics, Angle Orthodontist, Journal of orthodontics and the Journal of American Dental Association. Keywords and Medical Subject Heading (MeSH) terms were used with boolean operators “AND”. The relevant data was searched using the following keywords and their combinations: “aligners” (MeSH term) AND “orthodontic treatment” (MeSH term); “fixed appliances” (MeSH term) AND “orthodontic treatment” (MeSH term); “fixed mechanotherapy” (MeSH

term) AND “comprehensive orthodontic treatment” (MeSH term) AND occlusion (MeSH term); “cross bite” (MeSH term) AND “crowding” (MeSH term) AND “open bite” (MeSH term); “overbite” AND “overjet” (MeSH term).

Screening Process

The search and screening were carried out by two authors. A two-phase selection of articles was conducted. In phase one, titles and abstracts of all articles were reviewed by two reviewers. In phase-two, selected full articles were reviewed and screened by same reviewers. Any disagreement was resolved by discussion. When mutual agreement between two reviewers was not reached, a third reviewer was involved to make final decision. The final selection was based on consensus among all three reviewers.

Selection of Study

After removal of duplicates, screening of reference list of studies was done. After which 121 studies were excluded. Then eligibility of full text articles was checked and articles that did not meet inclusion criteria were excluded. Twelve studies fulfilled eligibility criteria and were included. While four studies were included in meta – analysis. A flowchart of identification, inclusion and exclusion of studies is shown in **Figure 1** below.

The articles retrieved in systematic review included features like comparison of treatment outcome between two appliances i.e., aligners and fixed mechanotherapy, ABO-OGS scoring, treatment duration and certain periodontal conditions like external root resorption, periodontal probing depth etc.

Quality Assessment

Cochrane risk of bias (ROB) -2⁵⁻⁶ tool was used. The tool has various domains like random sequence generation, allocation concealment, blinding of personnel and equipment's, blinding of outcome

assessment, incomplete outcome data, selective reporting, and other biases. The overall risk for individual studies was assessed as low, moderate, or high risk. For ABO-OGS scoring, each criterion is scored for specific teeth in upper and lower dentition; like all the teeth in upper and lower arches are scored for alignment, while buccolingual inclination and occlusal contacts are scored for 1st premolar to 2nd molar bilaterally in maxillary arch and 2nd premolar to 2nd molar in mandibular arch (1st premolars are not scored in mandibular arch). Occlusal relationships are scored for canine to 2nd molar bilaterally in maxillary arch but not in mandibular arch. Only maxillary dentition is scored for overjet while mandibular dentition is not scored.

Statistical Analysis

The standardized mean difference (SDM) was evaluated for overall pooled estimate. A random effects model (Der Simonian-Laird method) was used. All statistical analyses were performed using the Review Manager software 5.3.

3. Results

Study Characteristics

Among these studies, one was cohort study, two were randomised control trials, nine were post treatment effective study. The study with complete ABO- OGS⁷ eight components but the ABO- OGS score < 30 points failed to pass the criteria. One study reported on the ABO- OGS score of seven out of eight components. One study reported simply on two of the eight ABO-OGS components which were marginal ridges and buccolingual inclination. Eight studies reported on duration, though there was considerable disparity in the results. (Table 1)

Out of 12 studies, the studies included for meta-analysis were Djeu 2005⁸, Li 2015⁹, Preston 2017¹⁰, Borda 2020¹¹ whose outcomes were based on the treatment

duration and the ABO-OGS scoring. The malocclusions considered were Class I bimaxillary protrusion, Class II div 1, Class II div 2, severe crowding, generalised spacing or Class III. It included comparison with both the appliances and treatment with extraction as well as non-extraction protocol. The four studies included in the meta-analysis were Cohort study, RCT and Comparison study. The malocclusions present were treated Orthodontically either by extraction or non- extraction line of treatment. In all the four studies the appliances used were either aligners or fixed. The treatment outcome of studies included in systematic review were compared using ABO-OGS scoring system.

Risk of Bias

Studies were largely comparable in methodological quality. All studies had moderate to high risk. The highest risk of bias was seen for incomplete outcome data. Among the included studies, two studies (Borda et al. 2020 and Li et al. 2015)⁹⁻¹¹ had the high risk of bias. Random sequence generation and allocation concealment domains were given the lowest risk of bias while incomplete outcome data was given highest risk followed by blinding of participants and personnel. Risk of bias is depicted in **Figures 2 and 3** as shown below.

Comparison of Treatment Outcome

Four studies were involved in meta-analysis. Data was evaluated from 344 patients. The mean age of patients was 29.54 years and patients were evaluated both for fixed mechanotherapy (fixed mechanotherapy) and aligners. On average the treatment duration was 1.5 to 2 years for both the groups. The time considered for completion of treatment varied according to the time of malocclusion present like Class I bimaxillary protrusion, Class II div 1, Class II div 2, severe

crowding, generalised spacing or Class III. The changes achieved were evaluated based on the photographic records or plaster models taken during treatment and after treatment. The finishing and detailing were more précised in fixed mechanotherapy as minor corrections were possible.

A) Objective Grading System (Ogs) Score For Aligners And Fixed Mechanotherapy

The Std. Mean Difference was calculated, and the pooled estimates favours fixed mechanotherapy This signifies that the objective grading system (OGS) score for aligners and fixed mechanotherapy for treatment outcome is more for fixed mechanotherapy as compared to aligners, but it is not statistically significant ($p >0.05$).Both are more or less equal.By employing the random effect model the I^2 statistic showed high level of heterogeneity for all the pooled estimates.

B) Discrepancy Index Score (Di) For Aligners And Fixed Mechanotherapy

The Std. Mean Difference was calculated, and the pooled estimates favours fixed mechanotherapy. This signifies that the discrepancy index score (DI) score for aligners and fixed mechanotherapy is more for fixed mechanotherapy but for outcomes like overbite, crowding, buccal posterior cross-bite and cephalometric favours aligners and this difference is statistically significant ($p >0.05$). By employing the random effect model the I^2 statistic showed low to medium level of heterogeneity for all the pooled estimates.

Limitations Of Characteristic Study Table:

The limitations of the studies considered in table 1 is that the periodontal factors are not considered. Also, the patient satisfaction in both the groups in not

studied. The case which required any type of surgery were not considered.

4. Discussion

In this systematic review it condenses evidence from randomized trials, cohort study as well as comparison study based on the treatment outcome of orthodontic aligners and fixed orthodontic treatment. 12 studies were included, out of which 4 studies were included for meta-analysis based on the inclusion criteria.

There was statistically significant difference between the age groups in aligner and fixed mechanotherapy. This discrepancy existed because a greater number of adults opt for aligners because of aesthetic reason. Aligners are limited to patients with permanent dentition whereas fixed mechanotherapy can be given to adolescent children.

The DI measurement components included overjet, overbite, anterior open bite, lateral open bite, crowding, occlusion, lingual posterior crossbite, buccal posterior crossbite, cephalometric, and other. But analysis had no statistical difference between both the groups. Thus, overall severity of the malocclusion in both the groups were similar. The parameters assessed suggested that there was less efficiency in aligners group and had less emergency visit compared to fixed mechanotherapy. It is observed that aligners might not be able to produce adequate occlusal contacts as braces, probably because it is difficult for the aligners to extrude a tooth unless there is a significant undercut. Also, the aligners cover the occlusal surfaces of the teeth it prevents settling of the occlusion. As there is no breakage or impingement of wires in aligners, the emergency visits can be avoided.

Interestingly, there was a statistically significant difference between the treatment durations of the groups: 1.4 years for the Invisalign patients and 1.7

years for the fixed mechanotherapy patients. These data suggest that aligner treatment can be somewhat faster than fixed appliances. Although Invisalign can produce quicker results, the final occlusion might not be as ideal. Djeu G et al⁸ concluded that ABO-OGS scoring of aligner cases was inferior when compared to fixed mechanotherapy cases, suggesting that treatment results of fixed mechanotherapy is superior to those of aligners. OGS scores were comparatively similar in both groups for parameters like rotations, marginal ridge heights, space closure, and root alignment, but in aligner ABO-OGS scores for occlusal contacts, posterior torque, and A-P discrepancies were not good. Aligner ABO-OGS scores were substantially correlated to initial overjet and occlusion, and which indicated that aligners were insufficient to treat patients with large A-P discrepancies. With respect to treatment efficiency, the clear aligner groups finished their treatment 6 months earlier and with fewer appointments. According to Li et al⁹ there was no difference in the treatment duration between the aligners and fixed mechanotherapy. The shorter treatment duration with clear aligners in few studies might be due to severity of malocclusions in various treatment samples. ABO DI showed results in favour of aligners in parameters like crowding, buccal posterior crossbites and cephalometrics. Remaining parameters showed results in favour of mixed mechanotherapy. The OGS measurement components are alignment, marginal ridges, buccolingual inclination, occlusal contacts, occlusal relations, overjet, interproximal contacts, and root angulation. Based on evaluation of different components of ABO-OGS, the comparison between aligners and fixed mechanotherapy it can be concluded that the occlusal aspects mostly affected by the treatment modality. Few of the OGS categories produced statistically significant differences between both the treatment

groups. The aligner and fixed appliances had similar scores on alignment, marginal ridges, interproximal contacts, and root angulation. The fixed mechanotherapy had significantly superior scores for correcting buccolingual inclination, occlusal contacts, occlusal relationships, and overjet. The aligners can consistently produce adequate space closure of up to 6 mm by progressively tipping movement of teeth into spaces but in small increments. In terms of alignment, aligners have shown success in straightening the arches by derotating teeth, especially when composite attachments are given to premolars. According to Borda AF et al¹¹, when orthodontic patients in adolescence with mild malocclusions treated with either aligners or fixed appliances, cast evaluation measurement results showed comparable outcomes for marginal ridge positioning, buccolingual inclination, interproximal contacts, and occlusal contacts. In terms of evaluation of tooth alignment, occlusal relations, overjet, and overall cast radiographic evaluation scoring treatment with clear aligners for mild malocclusions resulted in significantly better results. According to Papageorgiou SN et al¹² most of the adult patients with mild to severe malocclusions when treated with or without extractions, the orthodontic treatment with aligners is associated with inferior treatment outcomes when compared to fixed appliances. Simon M et al¹³ reported bodily tooth movements such as molar distalization, incisor torque, as well as premolar derotation can be achieved using the Invisalign® system. Upper incisor torque and pure premolar derotation are challenging movements using removable thermoplastic appliances.

Limitations of The Study:

Methodological issues existed in the included studies which might affect the conclusion of this study. Selection bias may not be ruled out when non-

randomized designs are used; however, in an attempt to reduce the risk for such a potential limitation, we solely included studies with results showing treatment duration and ABO-OGS scoring to match baseline characteristics.

5. Conclusion

According to current evidence of systematic review and meta-analysis the treatment outcomes are better in fixed mechanotherapy as compared to clear aligners. ABO DI showed results in favour of aligners in parameters like crowding, buccal posterior crossbites and cephalometric. Whereas majority of parameters of ABO- OGS score were in favour of fixed mechanotherapy except for overjet. Treatment duration is unaffected by the type of appliance used, as the type of malocclusion present might play an important role. The overall outcome of orthodontic treatment is superior in case of fixed mechanotherapy.

6. References

- Lagravere MO, Flores-Mir C. The treatment effects of Invisalign orthodontic aligners: a systematic review. *The Journal of the American Dental Association*. 2005 Dec 1;136(12):1724-9.
- Kesling PC. Tooth positioner. Google Patents; 1968.
- Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group* T. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*. 2009 Aug 18;151(4):264-9.
- JPT H, S G. Handbook for Systematic Reviews of Interventions Version 5.1.0
- Higgins JP, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, Savović J, Schulz KF, Weeks L, Sterne JA. The Cochrane Collaboration's tool for

- assessing risk of bias in randomised trials. *Bmj*. 2011 Oct 18;343.
- Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, Henry D, Altman DG, Ansari MT, Boutron I, Carpenter JR. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *bmj*. 2016 Oct 12;355.
- Cangialosi TJ, Riolo ML, Owens Jr SE, Dykhouse VJ, Moffitt AH, Grubb JE, Greco PM, English JD, James RD. The ABO discrepancy index: a measure of case complexity. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2004 Mar 1;125(3):270-8.
- Djeu G, Shelton C, Maganzini A. Outcome assessment of Invisalign and traditional orthodontic treatment compared with the American Board of Orthodontics objective grading system. *American journal of orthodontics and dentofacial orthopedics*. 2005 Sep 1;128(3):292-8.
- Li W, Wang S, Zhang Y. The effectiveness of the Invisalign appliance in extraction cases using the the ABO model grading system: a multicenter randomized controlled trial. *International journal of clinical and experimental medicine*. 2015;8(5):8276.
- Preston KA. *Treatment and post-treatment posterior occlusal changes in Invisalign® and traditional braces: a randomized controlled* (Doctoral dissertation).
- Borda AF, Garfinkle JS, Covell Jr DA, Wang M, Doyle L, Sedgley CM. Outcome assessment of orthodontic clear aligner vs fixed appliance treatment in a teenage population with mild malocclusions. *The Angle Orthodontist*. 2020 Jul;90(4):485-90.
- Papageorgiou SN, Koletsi D, Iliadi A, Peltomaki T, Eliades T. Treatment outcome with orthodontic aligners and fixed appliances: a systematic review with meta-analyses. *European Journal of Orthodontics*. 2020 Jun 23;42(3):331-43.
- Simon M, Keilig L, Schwarze J, Jung BA, Bourauel C. Treatment outcome and efficacy of an aligner technique—regarding incisor torque, premolar derotation and molar distalization. *BMC oral health*. 2014 Dec;14:1-7.
- Robitaille P. Traitement combiné d'orthodontie et de chirurgie orthognatique avec Invisalign®: revue de la durée de traitement et des résultats obtenus.
- Abbate GM, Caria MP, Montanari P, Mannu C, Orrù G, Caprioglio A, Levrini L. Periodontal health in teenagers treated with removable aligners and fixed orthodontic appliances. *Journal of orofacial orthopedics*. 2015:1-0.
- Fetouh O. Comparison of treatment outcome of Invisalign® and traditional fixed orthodontics by model analysis using ABO Objective Grading System. State University of New York at Buffalo; 2009.
- Yi J, Xiao J, Li Y, Li X, Zhao Z. External apical root resorption in non-extraction cases after clear aligner therapy or fixed orthodontic treatment. *Journal of Dental Sciences*. 2018 Mar 1;13(1):48-53.
- Hennessy J, Garvey T, Al-Awadhi EA. A randomized clinical trial comparing mandibular incisor proclination produced by fixed labial appliances and clear aligners. *The Angle Orthodontist*. 2016 Sep;86(5):706-12.
- Gu J, Tang JS, Skulski B, Fields Jr HW, Beck FM, Firestone AR, Kim DG, Deguchi T. Evaluation of Invisalign treatment effectiveness and efficiency compared with conventional fixed appliances using the Peer Assessment Rating index. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2017 Feb 1;151(2):259-66.

Han JY. A comparative study of combined periodontal and orthodontic treatment with fixed appliances and clear aligners in patients with periodontitis. *Journal of periodontal & implant science*. 2015 Dec 1;45(6):193-204.

Lanteri V, Farronato G, Lanteri C, Caravita R, Cossellu G. The efficacy

of orthodontic treatments for anterior crowding with Invisalign compared with fixed appliances using the Peer Assessment Rating Index. *Quintessence Int*. 2018 Jan 1;49(7):581-7.

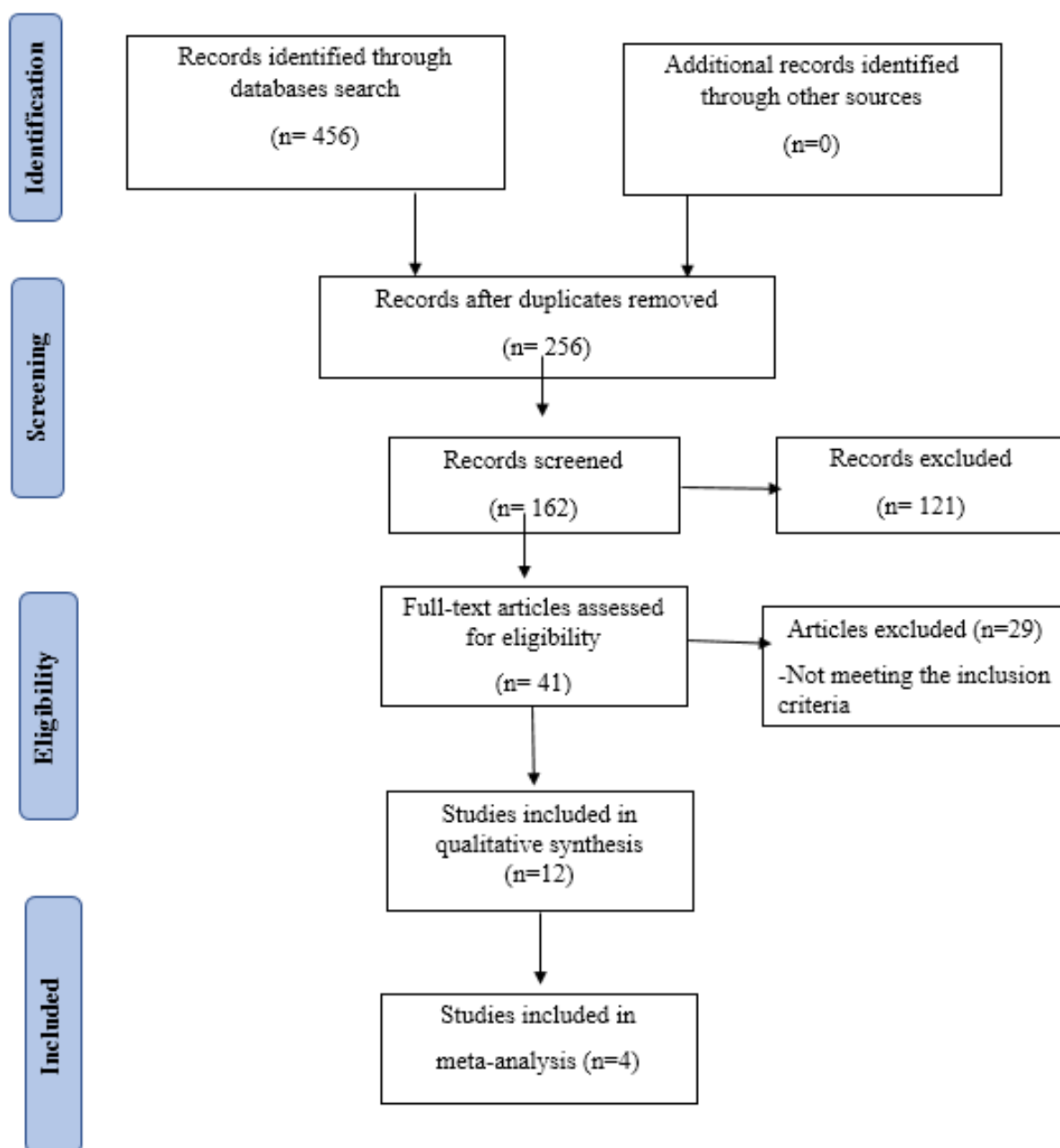


Figure 1: PRISMA 2009 Flow

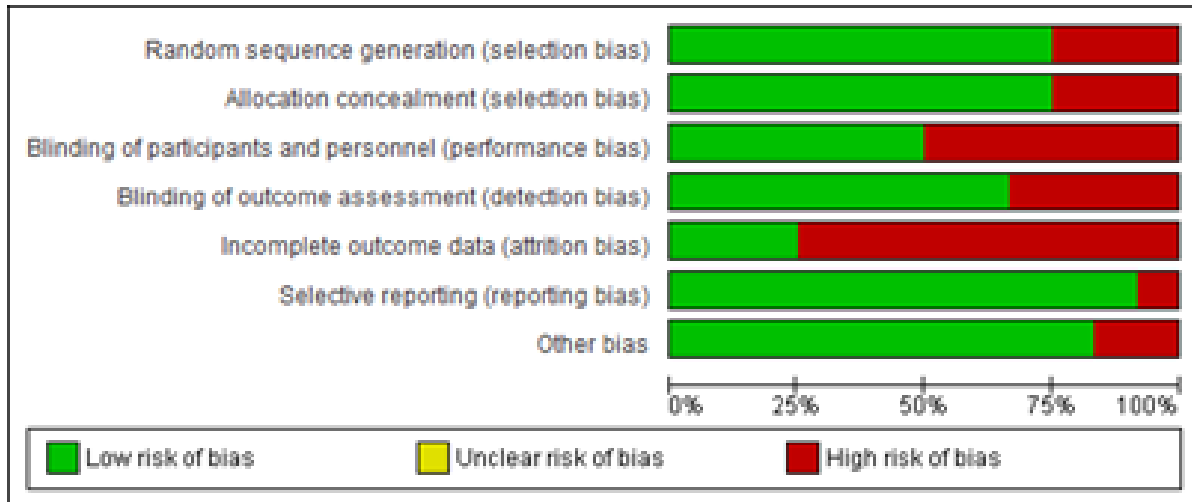


Figure 2: Risk of bias graph: review author’s judgements about each risk of bias item presented as percentages across all included studies.

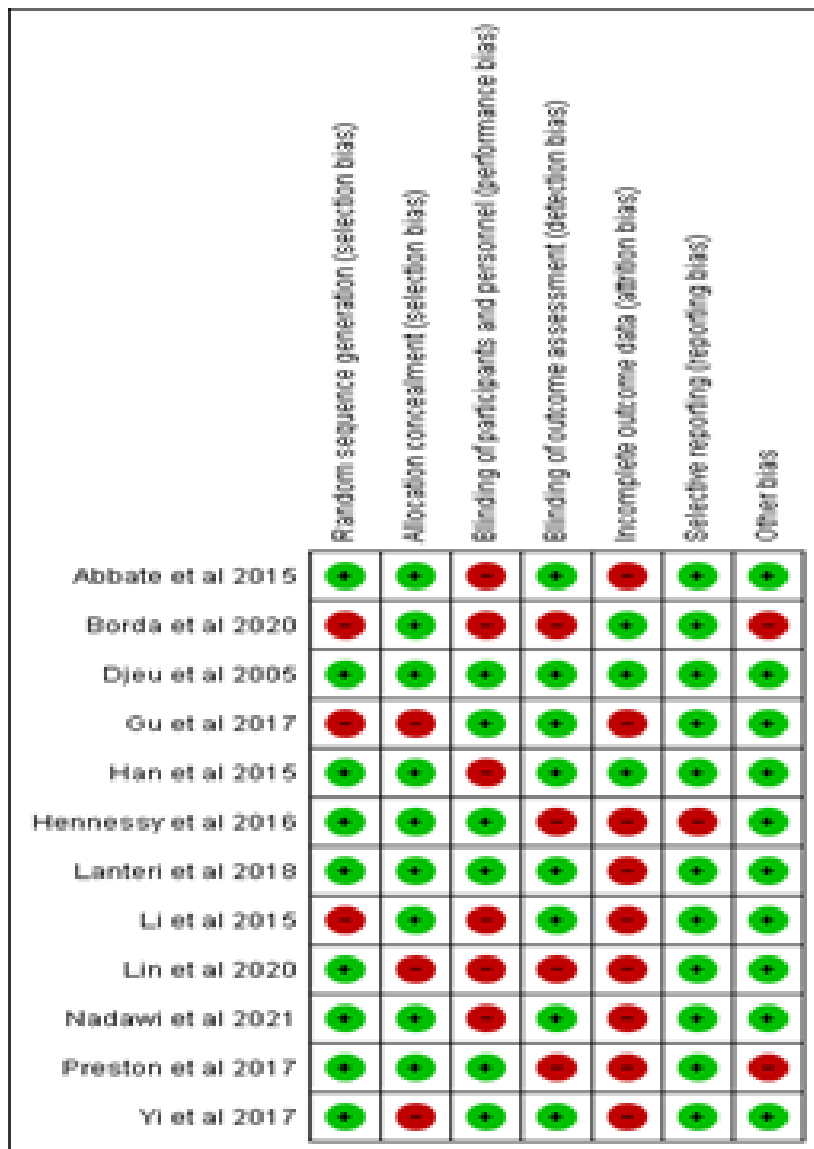


Figure 3: Risk of bias summary: review author’s judgements about each risk of bias item for each included study.

STUDY	STUDY DESIGN	PARTICIPANTS/AGE	MALOCCLUSION	APPLIANCE/AGE	MEASURES	OUTCOME
Djeu 2005 ⁸	Cohort Study	n=96 AL=48 FX=48	Extraction, Non-extraction	AL= Invisalign (33.6) FX= Labial CLB (23.7)	ABO-OGS Score, DI	1. Invisalign cases did not score as well as braces cases. 2. Invisalign OGS scores for occlusal contacts, posterior torque, and A-P discrepancies were not as good as those for braces. 3. Invisalign did not treat patients with large A-P discrepancies well. 4. Statistically significant correlations between treatment duration.
Li 2015 ⁹	RCT	n = 152 AL=76 FX=76	Extraction cases	AL= Invisalign (35.2±7.3) FX= Labial CLB (32.2±8.3)	ABO-OGS Score	Invisalign OGS scores for occlusal contacts and buccolingual inclination were not as good as those for braces.
Preston 2017 ¹⁰	RCT	n = 44 AL=22 FX=22	Non-extraction & mild crowding	AL= Invisalign (27.8) FX= Labial CLB (25.4)	ABO- OGS Score of marginal ridge and buccolingual inclination of posterior teeth	1. Treatment duration was significantly shorter in Invisalign than braces. 2. Traditional braces showed higher areas of contact than Invisalign®
Borda 2020 ¹¹	Comparison	n =52 AL=26 FX=26	Non-extraction & mild crowding	AL= Invisalign (13.7) FX= Labial SLB (13)	ABO-OGS Score ABO-DI score	1. The fixed appliance group averaged more treatment visits relative to the aligner group (19.36 3.6 vs 13.76 4.4). 2. The fixed appliance group averaged more emergency visits relative to the aligner group (3.66 2.5 vs 0.86 1.0). 3. Treatment time in the fixed appliance group was longer than in the aligner group (23.46 4.4 vs 16.96 5.7 months)
Robitaille 2016 ¹⁴	NRS	n=49 AL=24 FX=25	Orthognathic Surgery	AL= Invisalign (29.8) FX= Labial CLB (23.4)	ABO Phase III method	1. Mean scores were consistently higher for Invisalign® and there was a significant difference between the groups regarding alignment, occlusal contacts, root angulations and total score. 2. The duration of pre-surgical preparation and the total treatment time were shorter for the Invisalign® group (p ≤ 0.05).

Abbate 2015 ¹⁵	RCT	n =50 AL=25 FX=25	Extraction , Non-extraction	AL= Invisalign FX= Labial CLB (10-18 yrs)	The subgingival microbiological samples, probing depth (PD), plaque index (PI), and bleeding on probing (BOP) were recorded from the mesiovestibular subgingival sulcus	1.This study was not aimed at evaluating the orthodontic outcomes of two different approaches (fixed and removable) 2. During 12 months of orthodontic therapy, teenagers treated with removable appliances demonstrate better compliance with oral hygiene and present less plaque and gingival inflammatory reactions than their peers with fixed appliances.
Fetouh 2008 ¹⁶	NRS	n =66 AL=33 FX=33	Extraction , Non-extraction	AL= Invisalign (NR) FX= Labial CLB (NR)	Only literature search was carried.	Not enough studies were available to arrive at definite conclusions to compare clear aligner and fixed orthodontic treatment.
Yi 2018 ¹⁷	Comparison	n =80 AL=40 FX=40	Non-extraction	AL=Invisalign (21.80 ± 5.11) FX= Labial CLB (23.28 ± 5.60)	The digital panoramic radiographs were used to evaluate the root length before and after treatment.	The mean value of EARR in aligner group was 5.13 ± 2.81%, which was significantly less than that of fixed group (6.97 ± 3.67%).
Hennesy 2016 ¹⁸	RCT	n =40 AL=20 FX=20	Non-extraction & mild crowding	AL= Invisalign FX= Labial SLB (26.4 ±7.7 years)	The main outcome was the cephalometric change in mandibular incisor inclination to the mandibular plane post treatment	There was no difference in the amount of mandibular incisor proclination produced by clear aligners and fixed labial appliances in mild crowding cases.
Gu 2017 ¹⁹	NRS	n =96 AL=48 FX=48	Non-extraction	AL= Invisalign (26) FX= Labial CLB(22.1)	PAR index	1.Invisalign patients finished treatment faster than those with fixed appliances. 2. Results of Invisalign were compromised compared to fixed.

Han 2015 ²⁰	NRS	n =19 AL=10 FX=9	Non- extraction/ Periodont al disease	AL= NR FX= Labial CLB (52.97)	plaque index, the gingival index, and probing depth	No significant difference was found in both the groups
Lant eri 2018 ²¹	NRS	n =200 AL=100 FX=100	Non- extraction	AL= Invisalign FX= Labial SLB (28±10)	Little's index score PAR index	Invisalign showed significant improvement in PAR index score

Table 1: Descriptive study characteristics of included studies.

RCT= Randomised Control Trial, NRS= Non-Randomised Studies, AL= Aligners, FX= Fixed appliance, CLB= Conventional Ligated Bracket, SLB= Self Ligating Bracket, NR= Not Reported, CRE= Cast Radiographic Evaluation, EARR= External Apical Root Resorption, Tx= treatment duration