Treatment of Anterior Open Bite using Clear Aligners: A Meta Analysis

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Abstract

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Background: Anterior open bite (AOB) is a challenging malocclusion that can impact oral function and aesthetics. Clear aligner therapy has been used as a potential approach to correct anterior open bite. Nonetheless, consensus lacks on the success of aligners to correct AOB. Further, the mechanism by which aligners work has not been fully described.

Objectives: This study aimed to review the studies reporting on correction of anterior open bite with clear aligners to answer two main questions: (i) How successful is clear aligner therapy in treating anterior open bite? (ii) What are the mechanisms by which clear aligners achieve this correction (e.g., roles of Anterior teeth extrusion and Posterior teeth intrusion)?

Methods: To evaluate the effectiveness of clear aligners in correcting AOB, a meta-analysis was conducted based on PRISMA guidelines. Search of PubMed and ProQuest databases identified a total of 582 citations. Studies were included if they were retrospective or prospective case series evaluating adults with AOB treated exclusively with the Invisalign appliance and reported quantitative pre- and post-treatment measurements of open bite closure. Seven studies published between 2017 and 2024 met these criteria and were analyzed. The primary outcome for the analysis was the mean difference in open bite

correction achieved by the treatment. Robust meta-regression was used to examine the influence of AOB severity and treatment duration on the outcome. Additionally, we evaluated the relative contributions of Anterior teeth extrusion and Posterior teeth intrusion in achieving bite closure, using cephalometric analyses to quantify changes in tooth position and open bite correction.

Results: Identified studies were primarily conducted in the United States and Australia. The mean open bite correction across studies was 2.34 mm (95% CI: 3.22 to 1.47 mm). A trend towards decreased treatment efficacy was observed with increased AOB severity (coefficient = -1.58, 95% CI: -3.42 to 0.27, p = 0.06). Treatment duration, analyzed in a subset of five studies, however, was not significantly associated with treatment outcome(coefficient = 0.01, 95% CI: -0.60 to 0.62, p = 0.95). Anterior teeth extrusion was the primary mechanism contributing to AOB correction, supported by significant incisor extrusion reported in multiple studies(e.g., mean overbite correction of 3.27 mm, 95% CI: 2.95 to 3.59 according to Harris et al.). Posterior teeth intrusion was reported in one study, with minimal and inconsistent contributions from Posterior teeth intrusion across the studies.(e.g., molar intrusion of 0.1-0.6 mm according to Sara Finkleman et al).

Conclusion: The Invisalign appliance is effective in treating AOB in adults. The severity of initial AOB may influence treatment success, with more severe cases having worse outcomes. Anterior teeth extrusion is the primary mechanism for correcting anterior open bite.

Keywords: Anterior open bite, clear aligners, Invisalign, orthodontics, meta-analysis

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Chapter 1: INTRODUCTION

Anterior open bite (AOB) is a malocclusion characterized by a lack of vertical overlap or contact between the upper and lower anterior teeth when the posterior teeth are in occlusion[1]. The prevalence of AOB varies, affecting 2-11% of the population, being more common in certain ethnic groups and age ranges[2,3]. This condition can lead to esthetic concerns and may impact speech and mastication[2]. Clinically, AOB has been associated with tongue thrusting, altered speech patterns, and, in some cases, an increased risk of temporomandibular joint disorders and periodontal disease [13,14], though these complications remain a subject of debate within the orthodontic community

The management of AOB has included various orthodontic treatments that may or may not include orthognathic surgery. Orthodontic approaches traditionally involve the use of fixed appliances combined with elastics, or extractions to correct the vertical discrepancy.[5,6] Severe cases with skeletal etiology may necessitate orthognathic surgery to reposition the jaws and achieve proper occlusion.[3] Despite the effectiveness of these treatments, they are often associated with significant discomfort, extended treatment durations, and potential complications, which drive the need for less invasive and more patient-friendly alternatives.[7] Clear aligners, such as Invisalign, have emerged as an alternative primarily due to their aesthetic appeal and the preference of some patients for a removable, less visible option. An aligner system uses a series of custom-made, removable, and partly invisible plastic trays that incrementally move teeth into the planned position. The mechanism of action involves applying forces to the teeth, which can be optimized for specific movements like extrusion or intrusion.[8] Invisalign appliance offers aesthetic benefits and the convenience of being removable, which may appeal to patients who prefer less visible orthodontic treatment and

the ability to maintain their oral hygiene routines more easily. However, patient compliance is critical for success, and the treatment duration is similar to that of traditional braces.

The efficacy of aligner treatment to address AOB remains a topic of ongoing debate within the dental community. While some studies have reported successful results, others have highlighted challenges of achieving significant vertical changes without adjunctive procedures[2,9]. A key limitation of these existing studies is their small sample sizes, lack of control groups for comparison, and dependence on cephalometric radiographs as the primary data source. Additionally, some of these reports unfortunately propose mechanics of correction – specifically Posterior teeth intrusion of molars – which is not supported by their reported data. A meta-analysis or systematic review can consolidate existing findings to enhance our current understanding. However, no such study had addressed this goal at the time of this thesis. Two important questions can and ought to be addressed based on current available evidence: (i) What is the overall efficacy of the Invisalign appliance in correcting AOB in adult patients? and (ii) How do clinical factors (such as AOB severity and treatment duration) influence the treatment outcome?

This thesis aims to evaluate the efficacy of the Invisalign appliance in treating anterior open bite (AOB) in adult patients by analyzing the mean difference (MD) in open bite correction across studies using a meta-analysis. Additionally, it seeks to investigate the associations between clinical factors, specifically AOB severity and treatment duration, and the efficacy of the Invisalign appliance using robust meta-regression analysis. Furthermore, the thesis aimed to examine the clinical and biomechanical factors involved in AOB correction with the Invisalign appliance, particularly the roles of anterior teeth extrusion and posterior teeth intrusion.

The findings of this meta-analysis can have important implications for clinical practice, potentially guiding orthodontists in selecting the most effective treatment strategies for adult patients with anterior open bite. By better understanding the efficacy of the Invisalign appliance and the factors influencing treatment outcomes, this research can contribute to design of more personalized and successful treatment plans, ultimately improving patient satisfaction and long-term oral health.

Chapter 2: METHODS

2.1 Study Design:

This study is a meta-analysis of clinical studies examining the use of invisalign appliance for the treatment of anterior open bite (AOB) and investigation of whether clinical factors—such as AOB severity and treatment duration—influence efficacy of clear aligner therapy. It also examined dental changes associated with clear aligner treatment, particularly incisor extrusion and molar intrusion, to address the thesis's goal to explore the clinical and biomechanical mechanisms involved in AOB correction.

2.2 Search Strategy:

The meta-analysis was conducted using data from published studies on clear aligner treatment of AOB among adult patients. The search strategy was designed to comprehensively retrieve relevant literature, with support from library resources. The primary data for this meta-analysis was sourced from published articles systematically searched in databases including PubMed and ProQuest.

A comprehensive search strategy was employed to identify relevant studies. Key search terms include 'clear aligners,' 'Invisalign', 'anterior open bite treatment,' and 'treatment efficacy of clear aligners.' The screening and selection of studies for this meta-analysis were guided by the PICOS framework. The population of interest included adult patients with anterior open bite malocclusion, all treated with the Invisalign appliance. The primary outcomes of interest was the degree of open bite correction. In addition, we assessed the efficacy of the treatment by evaluating dental or skeletal changes, specifically focusing on the extent of incisor extrusion and molar intrusion observed in the studies.

12.3 Inclusion/Exclusion Criteria

This meta-analysis included retrospective prospective case series studies that evaluated the use of the Invisalign appliance for the treatment of anterior open bite (AOB) in adults. Eligible studies reported the amount of open bite closure in millimeters with quantitative pre- and post-treatment measurements. Participants were adults with permanent dentition, aged 18 years and older. The treatment utilized clear aligners exclusively, without any surgical interventions. Furthermore, studies provided detailed information on the biomechanics of clear aligner treatment plans or simulations for anterior open bite correction, including descriptions of tooth movements.

Studies that did not provide quantitative closure amounts or lacked pre- and post-treatment quantitative data were excluded. The analysis also excluded studies involving syndromic patients, individuals with craniofacial anomalies, those with mixed dentition, and pediatric patients. Furthermore, studies involving surgical interventions, other concomitant interventions, or the use of appliances in conjunction with Invisalign were not considered. No identified study evaluated Invisalign appliance and a comparator.

2.4 Data Extraction and Management

Data for this research was gathered from identified studies based on the search strategy. Data extraction was conducted using an Excel sheet that captured essential information for each study. The primary focus was on extracting data relevant to the use of the Invisalign appliance for the treatment of AOB, including detailed outcomes related to anterior teeth extrusion and posterior teeth intrusion.

For each study, data extracted included the first author, publication year, overbite correction, number of patients, average age, participant demographics, treatment details, and the method used to measure overbite correction as shown in **Table 1**. Additional details such as the summary statistic for correction effect and its variability, the severity of AOB, and the duration of treatment were also recorded. Each study's detailed information was further organized into categories including study design, sample size, participant demographics, treatment specifics, outcome measures, results for both primary and secondary outcomes, measurement time points, effect estimates, risk of bias, any reported conflicts of interest, and the success rate of AOB correction, including specifics on intrusion and extrusion.
To ensure consistency and accuracy, a standardized data abstraction form was employed across all studies. Extracted data were cross-checked for accuracy. This structured approach facilitated a comprehensive analysis, enabling a detailed evaluation of the efficacy of the Invisalign appliance in AOB treatment.

As part of the data extraction and management, we summarized the key findings from each study, including the observed changes in incisor extrusion and molar intrusion. This summary provided an overview of the common mechanisms reported across studies but did not involve additional statistical analysis.

2.5 Data Analysis

The primary goal of the meta-analysis was to evaluate the efficacy of the Invisalign appliance in treating AOB in adult patients. The analysis began with thorough data preprocessing to ensure that all key variables were accurately named and appropriately formatted for analysis. Specifically, the correction effect and its variability were renamed and converted to numerical

values to facilitate statistical computations. For studies that had missing data on treatment duration, the missing values were imputed using the mean treatment duration calculated across the entire dataset. This step was crucial in maintaining the integrity and completeness of the data, allowing for a robust analysis.

2.5.1 Statistical Analysis

The primary analysis involved calculating the effect size for each study, which was then weighted by its variance and analyzed using robust meta-regression. This analysis focused on determining the overall efficacy of the Invisalign appliance in correcting AOB, as reflected in the aggregated effect size across studies. The robust meta-regression was conducted using the 'robu' function in R, with AOB severity and treatment duration as the independent variables. The robust meta-regression approach was chosen for its ability to handle small sample sizes more robustly. The results of the meta-regression were summarized, and the regression coefficients were extracted to assess the influence of severity and treatment duration on treatment outcomes. To visualize the results, a forest plot was generated, displaying the effect sizes and their 95% confidence intervals across the included studies. Additionally, scatter plots were created to explore the relationships between AOB severity, treatment duration, and the effect size. These plots included linear regression lines to help identify trends and correlations in the data. All statistical analyses were performed using the R programming language. The 'robu' package was used for robust meta-regression, and ggplot2 was employed for visualization. The comprehensive approach taken in this analysis ensured that the study's findings were robust and reflective of the complex factors involved in AOB correction with the Invisalign appliance.

Chapter 3: RESULTS

The meta-analysis included seven retrospective and observational studies evaluating the efficacy of the Invisalign appliance in treating AOB among adult patients. The combined sample consisted of 360 participants, with individual study sample sizes ranging from 12 to 86 patients.

The findings of the robust meta-regression analysis revealed that the Invisalign appliance was generally effective in reducing AOB, with an overall mean correction of 2.34 millimeters (95%CI 3.22 to 1.47 millimeters)The variability in treatment outcomes across different studies is visually represented in a forest plot (**Figure 2**), highlighting the degree of open bite correction observed in each study and the corresponding confidence intervals. As demonstrated in the forest plot (**Figure 2**), the majority of studies demonstrated significant positive treatment effects.

The effectiveness of the Invisalign appliance in correcting AOB for each study is summarized in **Table 2**. This table illustrates the variability in treatment outcomes across different studies, with some studies demonstrating significant improvement, such as those by Harris et al.[4] and Moshiri et al[7,] and others, like the study by Blundell et al[2,] showing minimal correction.

In analyses to explore the factors that might influence the success of treatment, a trend towards decreased treatment efficacy was observed with increasing AOB severity. The regression coefficient for severity was found to be -1.58, with a confidence interval ranging from -3.42 to 0.27. Although the p-value was 0.06, just above the conventional threshold for statistical significance, the negative coefficient suggests that patients presenting with more severe forms of AOB may experience less improvement with Invisalign treatment. This observation was further supported by a scatter plot (**Figure 3**), which depicted a negative association between the severity of AOB and the effect size of the treatment. On the other

hand, treatment duration did not seem to influence the treatment outcome . The regression coefficient for treatment duration was 0.01, with a wide confidence interval (-0.60 to 0.62), and a p-value of 0.95. Notably, none of the studies included in this meta-analysis explicitly adjusted for the treatment duration. The duration was either consistent across the treatment groups or based on standard clinical protocols rather than individualized adjustments for severity. The scatter plot (**Figure 3**) illustrating the relationship between treatment duration and effect size showed no discernible pattern, further emphasizing the non-significant findings of the robust meta-regression.

In addition to the overall meta-analytic findings, several studies provided specific insights into the mechanisms of AOB correction using Invisalign. The following is a summary of the findings related to anterior teeth extrusion and posterior teeth intrusion across the included studies: Several studies provided information on correction of AOB and the effectiveness of Invisalign in achieving Anterior teeth extrusion and Posterior teeth intrusion. Kayla Harris et al[4] (2020) reported a mean overbite correction of 3.27 mm (SD: 1.09 mm), indicating significant vertical positioning changes of the incisors and suggesting effective incisor extrusion with Invisalign. Similarly, Heeyeon Suh et al[11] (2022) observed a mean overbite correction of 3.3 mm (SD: 1.4 mm) with adjustments in mandibular incisor positioning, further supporting the effectiveness of Invisalign in incisor extrusion. Hamad Burashed et al[8] (2023) found a mean overbite improvement of 1.5 mm and a mean absolute incisor extrusion of 1.4 mm, emphasizing the role of optimized extrusion attachments in enhancing incisor extrusion. However, Haylea L. Blundell et al[2] (2023) reported a mean overbite correction of only 0.60 mm, highlighting a discrepancy between clinically achieved and prescribed bite closure but confirming the potential for Anterior teeth extrusion with Invisalign. Regarding Posterior teeth intrusion, Harris et al [4](2020) reported slight negative changes in maxillary and mandibular molar positions, indicating minimal molar intrusion efforts. Sara Finkelman

et al[9] (2022) observed small amounts of molar intrusion (0.1-0.6 mm) in patients with planned molar intrusion (PMI), indicating that limited Posterior teeth intrusion can be accomplished with Invisalign. Similarly, Blundell et al[2]. (2023) investigated the role of posterior occlusal bite-blocks (POBBs) in the correction of AOB using clear aligners and found that the use of POBBs did not significantly influence the efficacy of open bite closure. Their results suggest that the primary mechanism for AOB correction with clear aligners is Anterior teeth extrusion, with minimal contribution from Posterior teeth intrusion. The study highlighted that the ClinCheck software's predicted outcomes often overestimated the clinical results, particularly in terms of posterior dental movements. Khosravi et al[10]. (2017) observed that the primary mechanisms of overbite correction with the Invisalign appliance were proclination of the mandibular incisors and intrusion of the maxillary incisors. Minimal changes in the vertical position of the molars were noted, suggesting that the appliance's effect on molar intrusion is limited. Furthermore, Finkelman et al[9](2024) demonstrated that prescribed molar intrusion, with or without virtual occlusal bite blocks, resulted in actual molar intrusion and assisted with anterior open bite correction in adult patients. Suh et al[11]. (2022) also highlighted that maxillary incisor extrusion and mandibular plane angle reduction are significant factors in open bite closure with clear aligners.

Chapter 4: DISCUSSION

This meta-analysis of data from seven retrospective and observational studies found that Invisalign is generally effective in treating AOB in adult patients, achieving a mean correction of 2.34 millimeters. However, the results also highlight substantial variability in treatment outcomes, with some studies demonstrating significant improvements while others showed minimal correction. This variability underscores the complexity of AOB treatment and suggests that patient-specific factors, including the severity of the malocclusion, may significantly influence treatment success.

The robust meta-regression yielded two insights. Firstly, there was a trend towards decreased treatment efficacy with increasing AOB severity. Although the p-value was slightly above the conventional threshold for statistical significance, the consistent negative trend suggests that Invisalign may be most effective for mild to moderate cases of AOB, with reduced effectiveness in more severe cases. This finding has important clinical implications, indicating that clinicians may need to assess the severity of AOB before recommending Invisalign as the sole treatment modality, and consider adjunctive treatments for more severe cases. Secondly, the analysis found no significant effect of treatment duration on the degree of open bite correction. This challenges the common assumption that longer treatment times necessarily yield better outcomes. Instead, it suggests that the quality and precision of treatment planning are possibly more crucial than the duration of aligner use in achieving optimal results. Clinicians should therefore focus on meticulous treatment planning rather than extending treatment duration, as a well-executed, shorter treatment plan may be equally effective.

In addition to the quantitative findings, the descriptive findings provided valuable insights into the biomechanical processes involved in AOB correction using Invisalign. Given the

complexity of the biomechanical processes involved in AOB correction, a descriptive approach was deemed appropriate. This approach allowed for a detailed exploration of how these factors contributed to treatment. Anterior teeth extrusion emerged as the primary mechanism for bite closure, consistently observed across most studies. This emphasizes the importance of optimizing anterior tooth movement in treatment plans to maximize the effectiveness of clear aligners. Conversely, the role of Posterior teeth intrusion was minimal and inconsistent. Studies such as Finkelman et al. (2024) reported small amounts of molar intrusion, but these findings must be interpreted cautiously due to the limitations of cephalometric measurements, which may introduce measurement errors. As a result, Posterior teeth intrusion should not be relied upon as a primary mechanism for AOB correction with clear aligners.

Despite the valuable insights provided by this meta-analysis, several limitations must be acknowledged. First, the inclusion of retrospective prospective case series is a serious limitation. Randomized controlled trials are required to provide reliable evidence on how Invisalign compares to orthodontic treatment with fixed appliances. Case-series studies are particularly prone to biases due to unrecognized and unevaluated dropouts and introduces potential biases. The wide confidence intervals observed in our analysis are likely due to the small sample size and the inherent variability across the included studies. These intervals reflect a higher degree of uncertainty around the effect estimates, necessitating cautious interpretation of the results. Additionally, the variability in study designs and treatment protocols contributed to the observed heterogeneity. Although robust meta-regression techniques were employed to mitigate this, they cannot entirely account for unmeasured confounders. Future research with larger, more diverse sample sizes is essential to achieve more precise and reliable estimates. Second, the reliance on cephalometric radiographs in many studies presents limitations due to potential measurement errors, such as head

positioning and landmark identification. These errors, especially concerning small movements like molar intrusion, may affect the reliability of the outcomes. The absence of explicit error margins in some studies further complicates the interpretation of these findings.

Third, excluding studies involving surgical interventions limits the generalizability of our findings to more complex AOB cases that may require such treatments. Thus, our conclusions are most applicable to mild to moderate AOB cases treated with clear aligners alone. Finally, the absence of traditional sensitivity analyses (including heterogeneity test) and publication bias assessments, although partially mitigated by the use of robust meta-regression, represents a departure from standard meta-analytic procedures[15]. While robust methods are designed to address many of the concerns typically explored in sensitivity analyses, the omission of these additional checks may leave some residual uncertainty regarding the influence of outliers or unpublished studies.

The findings of this meta-analysis can contribute to and expand upon the existing research on the treatment of AOB with clear aligners, particularly in understanding the efficacy of Invisalign. While foundational studies by Ngan & Fields[3] (1997) and Subtelny & Sakuda[13] (1964) established key insights into the etiology and traditional management of AOB, they did not address the non-surgical potential of clear aligners. Research by Mizrahi[5] (1978) and Pisani et al. [6](2016) further underscored the complexities of treating AOB, especially the challenges in achieving long-term stability without surgical intervention. In this context, the advent of clear aligners like Invisalign introduced a significant shift in treatment modalities, offering a less invasive alternative. However, previous studies, such as those by Harris et al.[4] (2020) and Suh et al.[11] (2022), have reported mixed success, with varying degrees of correction achieved. Our meta-analysis provides a more comprehensive assessment of the effectiveness of Invisalign, particularly highlighting the variability in treatment outcomes that

had not been fully explored in earlier studies. The results align with Todoki's [14](2019) findings from the University of Washington, where 81% of AOB cases treated with Invisalign were corrected. However, our analysis goes further by quantitatively examining the impact of AOB severity and treatment duration on outcomes, offering new insights into the specific clinical factors that may influence success. We also emphasize the critical need for further investigation into the biomechanical mechanisms of clear aligners, particularly the roles of Anterior teeth extrusion and Posterior teeth intrusion, which remain underexplored despite their importance in achieving successful bite closure.

While this meta-analysis provides valuable insights into the efficacy of Invisalign in treating AOB, it also highlights areas where further research is needed. Future studies should clarify the mechanisms by which clear aligners achieve AOB correction, particularly the roles of Anterior teeth extrusion and Posterior teeth intrusion. While our analysis suggests Anterior teeth extrusion is the primary mechanism, the role of Posterior teeth intrusion remains unclear and warrants further investigation. Moreover, research should focus on refining treatment protocols to improve predictability and outcomes, especially in severe AOB cases. The observed variability suggests a need for personalized treatment approaches that consider patient-specific factors, such as the severity of malocclusion and anatomical differences. More studies with clear assessment of the mechanisms for improvement, especially of non-Invisalign aligner systems are needed to expand our understanding of AOB correction with aligners. Lastly, long-term follow-up studies are essential to assess the stability of AOB correction with Invisalign. Understanding whether these improvements are maintained over time or if relapse occurs is crucial for determining the long-term efficacy of clear aligners.

Chapter 5: CONCLUSION

In conclusion, this meta-analysis provides evidence supporting the efficacy of Invisalign in treating AOB among adult patients, particularly in cases of mild to moderate severity. The findings highlight the significant improvement in open bite correction achieved with Invisalign, while also underscoring the need for individualized treatment planning and further research to address the high variability in outcomes. These insights have important implications for clinical practice, public health initiatives, and future research, ultimately contributing to the advancement of orthodontic care.

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TABLE 1: Data Extraction Form

Study	Design	Sample Size	Age (Mean ± SD)	Severity (mm)	Treatment Duration (months)	Correction Effect (Mean ± SD)	Primary Outcome	Key Findings
Khosravi et al. (2017)	Retrospective	12	34.0 ± 11.0	-1.10	18.0	1.30 ± 0.60	Overbite improvement	Significant improvement in overbite with clear aligners, extrusion of maxillary incisors, and maintenance of molar positions.
Harris et al. (2020)	Retrospective	45	27.0 ± 6.0	-1.21	14.0	3.27 ± 1.09	Molar intrusion	Effective molar intrusion with clear aligners, maintaining vertical dimension, significant improvement in overbite.
Moshiri et al. (2017)	Retrospective	30	35.0 ± 7.0	-1.80	22.0	3.30 ± 1.40	Anterior open bite correction	Significant anterior open bite correction with clear aligners, combined with maxillary molar intrusion.
Suh et al. (2022)	Observational	69	33.0 ± 8.0	-2.21	20.0	3.30 ± 1.40	Incisor extrusion and molar intrusion	Effective in providing incisor extrusion and limited molar intrusion, maintaining vertical dimension.
Finkleman et al. (2024)	Retrospective	42	32.8 ± 10.9	-1.80	16.0	3.20 ± 1.70	Vertical molar movement	Effective treatment with clear aligners showing minimal vertical molar movement and high treatment success rate.
Blundell et al. (2023)	Retrospective cohort	76	35.2 ± 2.2	-1.20	18.5	0.60 ± 1.21	Tooth movement (molar intrusion and incisor extrusion)	Consistent results in maxillary molar intrusion and incisor extrusion, effective in open bite correction.
Burashed et al. (2024)	Retrospective cohort	86	29.0 ± 5.5	-1.30	22.5	1.50 ± 1.20	Anterior open bite correction	Effective in correcting anterior open bite with clear aligners, showing significant incisor extrusion.

TABLE 2: Summary of findings from included studies

Study	Sample Size (n)	Mean Open Bite Correction (mm)	Standard Deviation (SD)	95% Confidence Interval (CI)
Roozbeh Khosravi et al.	12	1.30	0.60	[0.96, 1.64]
Kayla Harris et al.	45	3.27	1.09	[2.95, 3.59]
Shuka Moshiri et al.	30	3.30	1.40	[2.80, 3.80]
Heeyeon Suh et al.	69	3.30	1.40	[2.97, 3.63]
Sara Finkleman et al	42	3.20	1.70	[2.69, 3.71]
Haylea L. Blundell et al.	76	0.60	1.21	[0.33, 0.87]
Hamad Burashed et al.	86	1.50	1.20	[1.25, 1.75]

FIGURE 1: PRISMA Flow Diagram for Study Selection

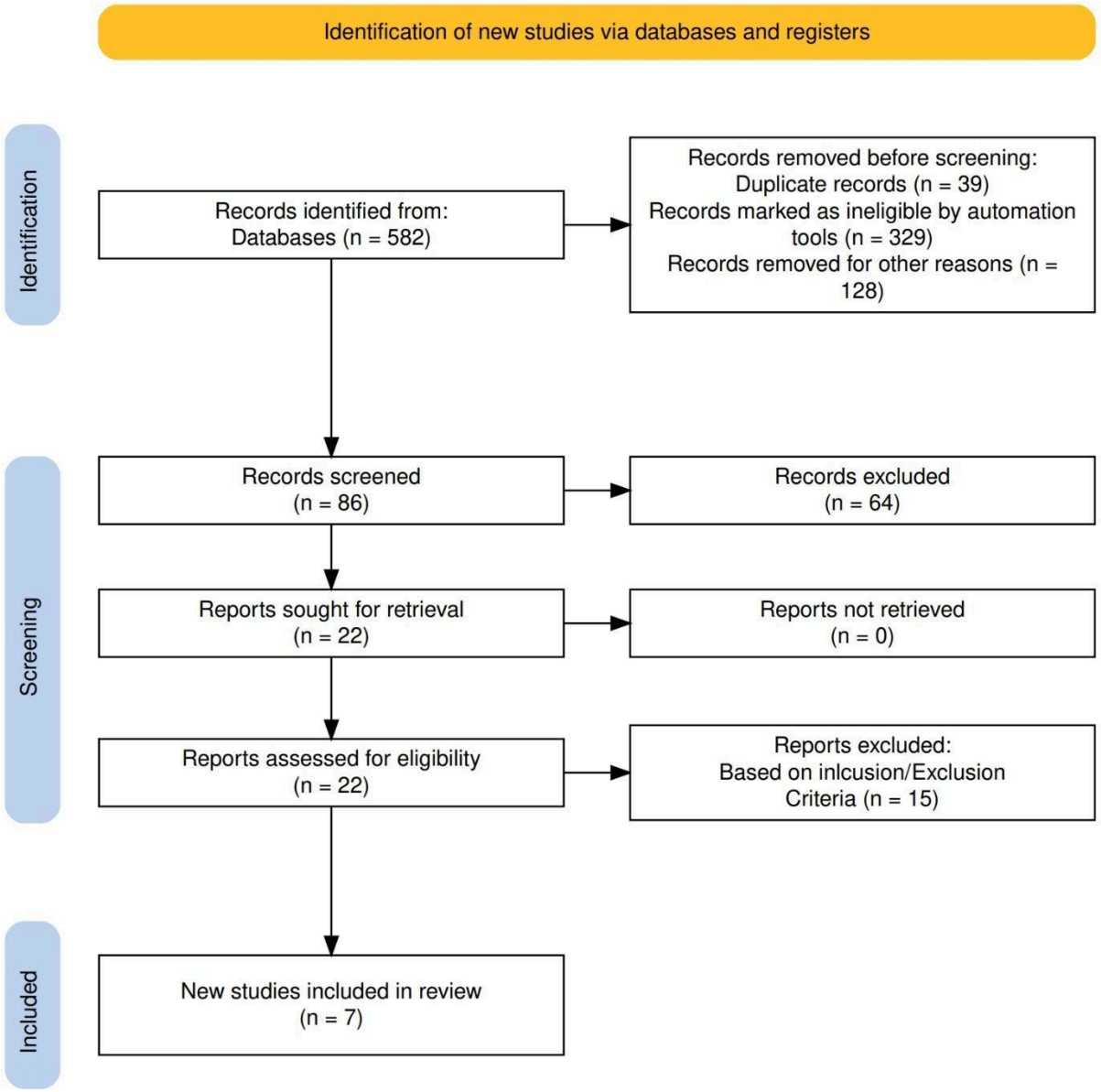

FIGURE 2: Robust Meta-Analysis Forest Plot of Effect Sizes for AOB Correction with Invisalign

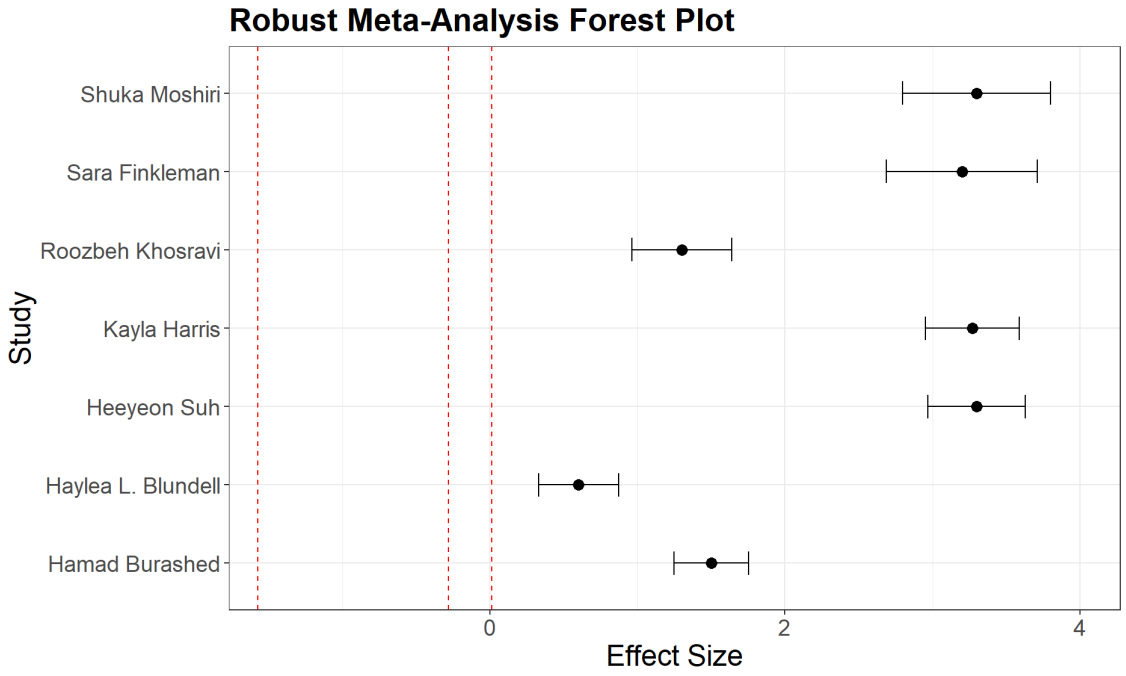

FIGURE 3: Scatter Plot of AOB Severity vs. Treatment Effect Size in Invisalign Correction

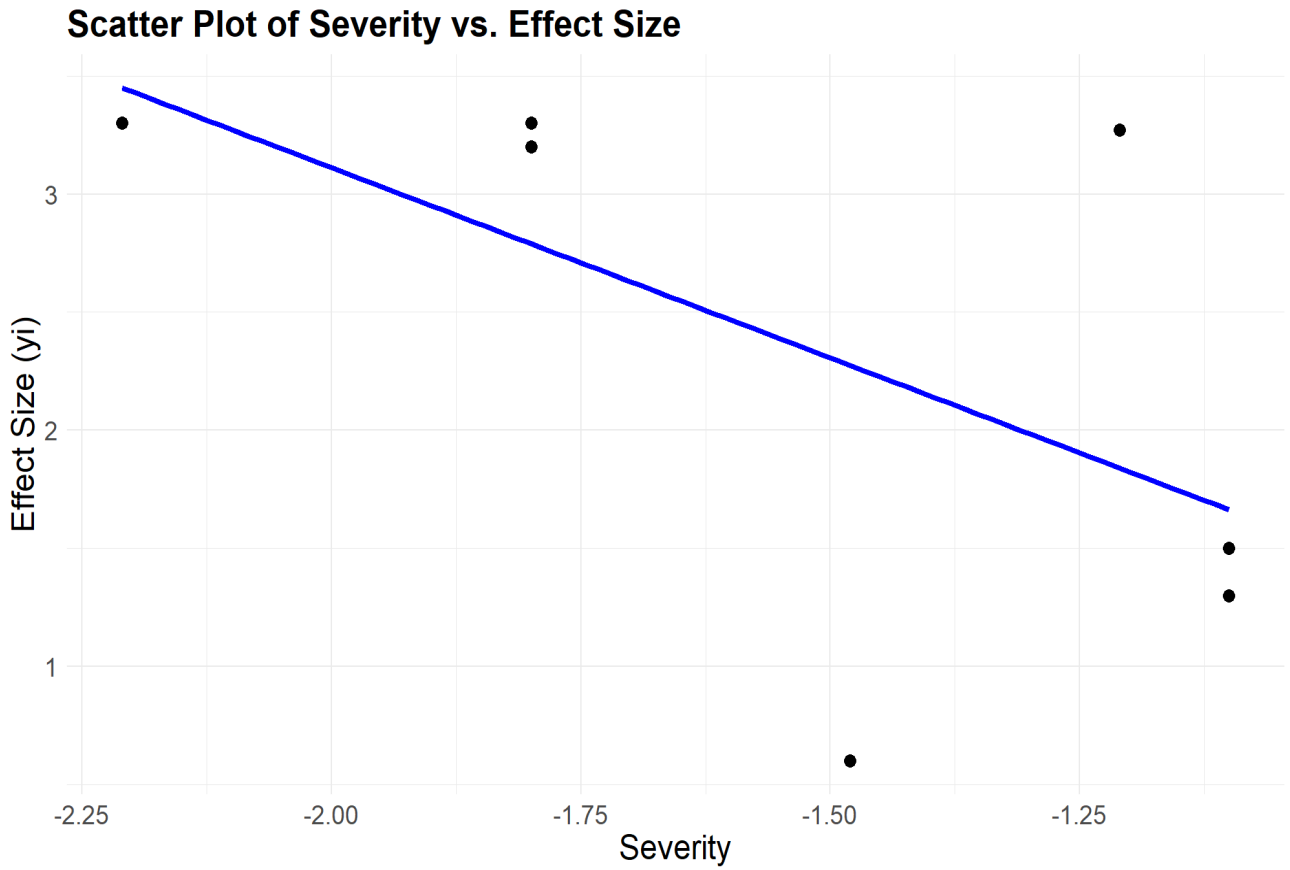

FIGURE 4: Scatter Plot of Treatment Duration vs. Effect Size in Invisalign Treatment of Anterior Open Bite