

Retention, Relapse and Stability of Openbite Malocclusion Treated with Clear Aligners: A Systematic Review

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ABSTRACT

Background: Clear Aligner Therapy (CAT) is gaining popularity and being increasingly utilized for difficult Open bite malocclusion cases as we progress. However, evidence for retention practices, relapse and long-term stability of this treatment remains inconsistent. Hence, this systematic review was carried out in an attempt to comprehend evidence regarding CAT for the aforementioned areas in treatment of Openbite malocclusion.

Objective: To identify, appraise and critically compare evidence on post-treatment retention, relapse, and stability in patients with open bite treated with Clear Aligner Therapy.

Materials and Methods: The review was planned, designed and reported complying PRISMA 2020. No language or publication-status restrictions were set while searching across the databases, including PubMed/MEDLINE, Embase, Web of Science, Scopus, Cochrane Library, Nature, Ovid, and Google Scholar. PICOS criteria were followed for defining eligibility. Randomised controlled studies along with Case reports/series, which evaluated CAT in non-surgical open-bite correction, were included. Methodological quality and risk of bias were assessed by three independent reviewers using ROBINS-I tool.

Results: Out of total ten included studies, majority were carried out using lateral cephalometric analysis and only in adult patients' population. Studies showed clear aligners to be an effective option for vertical control during open bite correction treatment with a favourable short-term stability. Best reported long-term stability was seen in patients with combined fixed bonded and removable (vacuum-formed) retainers; and tongue posture seemed to be a contributing factor in relapse.

Conclusion: Clear Aligner Therapy is a clinically viable treatment option for treating open bite malocclusion, with maintenance and stability of correction being highly reliant on the control of functional habits, the retainer design and patients' compliance. Long-term post-treatment retention phase follow-up studies with standardised retention outcomes are required and yet to fill the lacunae.

Keywords: Open Bite; Clear Aligner Treatment (CAT); Retention, Relapse; Stability.

How to cite this article: Dr. Keyuri Chavda, Dr. Aakash Shah, Dr. Bhagyashree Desai, Dr. Manisha Tripathi, Dr. Ahuti Shah, Dr. Neel Shah, Dr. Rutvi Shah, Retention, Relapse and Stability of Openbite Malocclusion Treated with Clear Aligners: A Systematic Review, Int J Drug Deliv Technol. 2026;16(80s): 1174-1184; DOI: 10.25258/ijddt.16.80s.147

INTRODUCTION

Rationale

Open Bite is typically defined as a lack of vertical overlap between the upper and lower front or the back

teeth. This might not be merely a dental malocclusion but also involving a significant vertical skeletal discrepancy amongst the jaws or a combination.

Over the past decades, orthodontists have been determined for a predictable treatment for vertical discrepancies, representing a move away from simple tooth movement to complex structural management.

Early practitioners regarded open bite as one of the most challenging malocclusions to treat and most challenging to retain and stabilise. Early 20th century orthodontists identified that their open bite patients continued to experience high rates of relapse; which led to continual investigation into the eminent effective forces and the biological restrictions of the human jaw.^[1]

Accurate radiological analysis along with clinical insights collectively are essential for precise diagnosis of an open bite case. Patients frequently exhibit a distinctive "long face" appearance with increased lower facial height and lack of lip competency. Beyond aesthetics, this type of malocclusion impairs speech. Cephalometric analysis being the "gold standard" here, helping us distinguish between a true skeletal imbalance and/or a habit-related dental malocclusion.^[2] It is a considerable clinical challenge to design a carefully balanced and individualised treatment plan for an open bite case. Age, growth potential, severity and type of the underlying skeletal and dental discrepancy are major factors to be considered in treatment planning. A wide array of treatment modalities, including interceptive (myofunctional therapy & habit-breaking appliances) as well as more complex (orthodontic camouflage or orthognathic surgery) appliances for non-growing individuals are available. An approach for treatment with biomechanics at the core, for open bite correction via bringing about the anterior teeth into function and to ensure stability thereafter, by either controlling the extrusion of the anterior teeth, the intrusion of the posterior teeth, or both, are of utmost importance.

Conventional fixed mechanotherapy can sometimes have an "extrusive" effect on molars, worsening already existing open bite malocclusion; whereas, clear aligners offer a unique mechanical advantage as the material itself seats on the occlusal tooth surfaces and act as a bite-block. The aligner thickness on the occlusal surfaces helps ensuring the prevention of posterior teeth extrusion and hence contributing to open bite correction.^[3]

The evolution of modalities ranging from conventional to Temporary Anchorage devices (TADs) to tech-enabled and steered CAT, certainly is a progressive step forward in orthodontic practice. The incorporation of three-dimensional(3D) treatment planning has allowed precise as well as controlled tooth movement and force application, ultimately leading to enhanced predictability and clinical efficiency of open-bite

correction by CAT compared to traditional techniques.^[4]

Long-term stability of open bite correction still remains a burning controversy, even with the evolving contemporary treatment modalities. Relapse rates, which were often high, have been reported in the earlier literature, which constantly raises questions about treatment outcomes and stability. With increasing demand and popularity for CAT, the evidence available surely pertaining to the same, surely is limited.

This systematic review aims to assess retention protocols, relapse rate and overall stability of treatment for open bite in adult patients treated with Clear Aligner Therapy.

Objectives

This systematic review was conducted with objectives to apprehend evidence that includes prospective/retrospective Controlled Trials, case reports, cohort studies, case series, and Randomised Controlled Trials (RCTs) on the short- and long-term retention, relapse and stability outcomes of non-surgical open bite malocclusion treatment with clear aligners. An added objective was to identify & examine potential factors influencing treatment outcomes.

MATERIALS AND METHODS

Protocol and Registration

The present review was designed using the Cochrane Handbook for Systematic Reviews of Interventions and reported in accordance with the PRISMA 2020 statement and the extension for abstracts. Prior to commencement, the systematic review was registered on PROSPERO. [Reg. number: CRD42025642635].

Literature screening and search strategy

Electronic databases for data collection were searched until 30th September 2025, addressing all the relevant literature on open bite management with clear aligner and retention, relapse and stability outcomes; namely PubMed (MEDLINE), Embase, Web of Science, Scopus, Cochrane Library, Nature, Ovid and Google Scholar.

There were no restrictions kept for language, year and date of publication. The search included MeSH terms in PubMed, and free-text terms. Majority of these terms included "open bite", "clear aligner", "retention", "relapse", "stability", and "follow-up" period. Boolean operators were used. A detailed systematic search strategy is given in [Table 1] to focus on relevant results from the databases. All eligible studies and all relevant articles from the electronic searches were manually read in the reference lists to look for further studies which were not identified through the electronic searches. Google Scholar and grey literature were also examined.

Table 1: Systematic search strategy

The focus question	Retention, Relapse, and Stability of Open Bite Malocclusion Treated with Clear Aligners
Search strategy	
1. Aligners OR Invisalign OR (clear aligners) OR (transparent aligners) OR (removable thermoplastic appliance) 2. Retention 3. relapse 4. stability AND Open bite	
Search combinations	AND, OR
Electronic databases	PubMed/MEDLINE, Embase, Web of Science, Scopus, Cochrane Library, Nature, Ovid, and Google Scholar.

Data Collection, Items and Analysis

Initially, the title and abstract were read by three authors (C. KB, D. BB and T. MP) separately. If the title and abstract did not provide sufficient information fitting the inclusion criteria, the full text was read to decide inclusion and exclusion of the article/studies.

Eligibility Criteria

The inclusion and/or exclusion for the present review was defined and specified following the PICOS criteria [Table 2].

Table 2: Inclusion and exclusion criteria

Category	Inclusion Criteria	Exclusion Criteria
<u>Population (P)</u>	- Human subjects presenting with open bite malocclusion of any age or gender - Non-surgical and non-syndromic patients.	- Patients with craniofacial syndromes, cleft lip/palate, or severe facial malformations. - Patients presenting with a deep bite. - Patients with temporomandibular joint (TMJ) disorders. - Animal studies.
<u>Intervention (I)</u>	- Orthodontic treatment using clear aligner therapy (Invisalign® or equivalent systems). - Aligner therapy with or without clinical adjuncts (e.g., intermaxillary elastics, attachments, IPR, or Temporary Anchorage Devices/TADs).	- Surgical treatment of open bite (e.g., orthognathic surgery). - Traditional fixed or removable appliances (conventional braces) without clear aligners.
<u>Comparison (C)</u>	Non-surgical orthodontic treatment modalities.	
<u>Outcome (O)</u>	- Studies reporting on retention protocols, relapse rates, and post-treatment stability. - Evaluation via clinical parameters or cephalometric assessments (angular skeletal, dentoalveolar, and soft tissue measurements) during a distinct follow-up period.	- Studies providing linear measurements on lateral cephalograms without reporting the respective magnification factor. - Evaluation restricted purely to electromyographic data or cost-benefit analyses.
<u>Study Design (S)</u>	- Original prospective or retrospective clinical studies: - Randomised Controlled Trials (RCTs) - Prospective Controlled Clinical Trials (pCCTs) - Well-documented case series or case reports with adequate statistical analysis reviews.	- Desk evaluation pieces: Editorials, editor's choices, author debates, replies, or commentaries. - Incomplete data sets: Abstracts only, conference/book abstracts, summaries, ongoing studies, or expert opinions unsupported by clinical data. - Studies with missing/inappropriate data.

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Data extraction and management

Full-text articles were checked according to eligibility criteria. Any disagreements regarding the inclusion of study selection were resolved by discussion with the fourth author (S. AB).

The following information was determined for the articles:

- Authors names
- Publication year
- Study design
- Number and groupings of participants
- Type of intervention
- Outcome

Quality of the Studies and Risk of Bias in Individual Studies

Quality assessment was performed using validated tools appropriate to the study design. The Cochrane Risk of Bias (RoB 2) tool was applied to randomised controlled trials, while the ROBINS-I (Risk of Bias in Non-randomised Studies of Interventions) tool was applied for prospective and retrospective cohort studies, case series, case reports, and controlled clinical trials.

The ROBINS-I utilised to assess bias across domains, including confounding, selection of participants, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of the reported results. Based on these criteria, studies were categorised as having low risk of bias, some concerns, or high risk of bias, which appraised the overall quality of included methodological evidence and judgements were synthesised subsequently to generate overall risk of bias.

RESULTS

Study selection

The database search identified 487 literature references in PubMed/MEDLINE, 389 in ScienceDirect, 126 in Google Scholar, 104 in Wiley, 12 in Nature, 6 in Ovid, and 0 in the Cochrane Library, for a total of 1,124 reference titles identified through database and manual searches. After reading the titles and abstracts, 996 titles were removed, including all duplicates and those deemed irrelevant. Finally, after full-text reading and analysis of 128 potential articles, only 10 studies met the pre-established eligibility criteria [Figure 1].

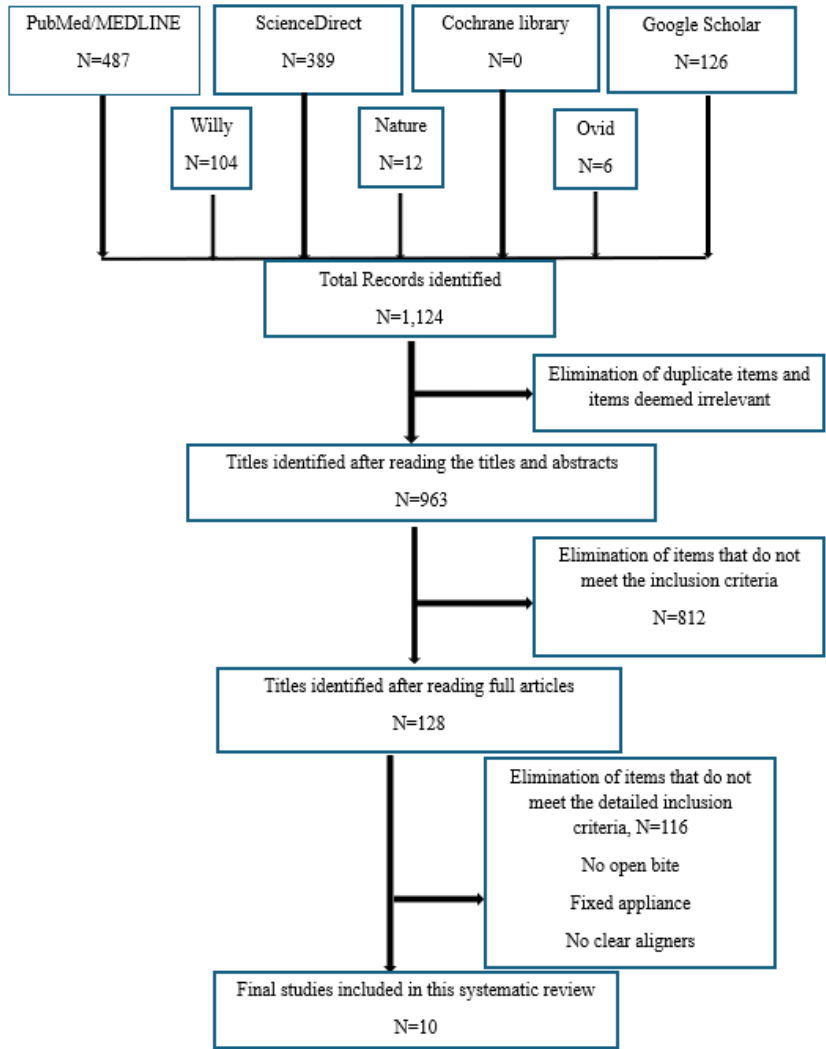


Figure 1: Flow diagram of the systematic review

Significantly, this analysis bridges a critical gap in the literature; to date, no systematic reviews or randomised controlled trials (RCTs) have investigated this combined retention protocol for open bite correction.

Study characteristics

Details of the different studies included are mentioned in [Table 3]. The flow diagram of the PRISMA guidelines is presented for the selection process of studies that met the inclusion criteria; these studies were Cohort studies, Case series, and Case reports. Furthermore, detailed information regarding clinical outcomes in terms of retention protocols, relapse rates and long-term stability of an open-bite correction is depicted in [Table 3].^[5-14]

Total number of studies included was ten, an aggregate of 1124 participants were included across all the studies. And all of them invariably involved Clear Aligner Therapy (CAT). The principal method of assessment for the stability of results and relapse in majority of selected studies was lateral cephalometric analysis. The literature reviewed comprised studies that

measured changes in overbite, vertical dimension control, relapse rate and overall post-treatment stability as primary outcomes. The results were evaluated post treatment employing a clinical and cephalometric assessment.

Moreover, the studies explored the biomechanical aspects involved in bite closure, specifically posterior molar intrusion and anterior incisor extrusion to determine their contributions towards treatment outcomes. The efficiency of the various types of retainers (bonded, vacuum-formed retainers (VFR), combination (bonded + VFR)) was analysed as well for their role in reducing chances of relapse and ability to maintain stability. The effects of using an adjunctive approach (intermaxillary elastics and temporary anchorage devices, etc) on treatment efficiency and stability were also examined. Patient-related factors were recognised as eminent factors in predicting the stability of treatment and risk of relapse including tongue posture, tongue thrust and myofunctional habits, indicating that open bite correction and retention require a multifactorial approach.

Table 3: Overview of the characteristics of included studies

Authors /	Study	Sampl	Intervention	Comparis	Retentio	Follow-	Primary
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Year	Design	Sample Size (N)	Group	Comparison Group	Retention Protocol	Follow-up Duration	Outcome(s)
Suh et al. 2023 ^[5]	Retrospective Cohort	52 adults	Clear aligners (non-extraction)	Pre- vs Post- vs Retention	Bonded (fixed) + Vacuum-formed (nightly)	2.1 ± 1.1 years	94% stability rate; mean relapse only 0.2 mm. Tongue posture identified as a predictor of relapse.
Karalikkattil et al. 2024 ^[6]	Retrospective Cohort	50 adults	Invisalign for AOB correction	Pre-treatment baseline	Not specified	Immediate post-treatment	Significant OB improvement (mean -3.5 to +1.5 mm); 90% patient satisfaction.
Todoki et al. 2020 ^[7]	Prospective Cohort	232 adults	Aligner treatment	Fixed appliances (FA) Temporally anchorage devices (TADs) Orthognathic surgery	Not specified	Immediate post-treatment	The primary outcome of the study was defined by a positive overbite on post-treatment cephalometric films and a score of 0 on the Photographic Openbite Severity Index (POSI), with the latter being used for most analyses.
Harris et al. 2020 ^[8]	Retrospective Study	45 adults	Clear aligners (Invisalign)	Pre-treatment vs. post-treatment	Not specified	Immediate post-treatment	Correction via U1 retraction (10.9°) and molar intrusion (0.23 mm).
Garnett et al. 2019 ^[9]	Comparative Retrospective	53 (36 CA, 17 FA)	Clear aligners with occlusal bite-blocks	Fixed appliances (n=17)	Not specified	Immediate post-treatment	No significant differences in vertical control between CAT and fixed appliances.
Steele et al. 2022 ^[10]	Comparative Cohort	53 (29 CA, 24 MSPI)	Clear aligners (CAT)	Miniplate-supported intrusion (MSPI)	Not specified	Immediate post-treatment	MSPI showed greater molar intrusion (1.5 mm) than CAT (0.5 mm).
Rask et al. 2021 ^[11]	Comparative Study	60 (30 CA, 30 FA)	Clear aligners (CAT)	Traditional fixed appliances	Not specified	Immediate post-treatment	CAT achieved better vertical molar control; FA showed more molar extrusion.
Moshiri et al. 2017 ^[12]	Prospective	30 adults	Invisalign (non-extraction)	Baseline cephalometric	Not specified	Immediate post-treatment	Mean OB change 3.4 ±

			extraction)	tric		treatment	1.4 mm; correction via incisor extrusion + molar intrusion.
Sabouni et al. 2022 ^[13]	Case Series	3 cases	Clear aligners (CAT)	Severity-based groups	Bonded (fixed) + Vacuum-formed	12–24 months	Anterior open bite closure (overbite improvement), incisor extrusion, posterior molar intrusion, cephalometric and occlusal changes.
Greco et al. 2021 ^[14]	Case Report	Adult case	CAT + Micro-osteoperforations	3-year follow-up	VFR	3 years	Long-term stability was demonstrated using MOPs to facilitate molar intrusion.

Risk of Bias Assessment

Quality assessment of the ten studies performed using ROBINS-I are shown in [Table 4]. However, funnel plots or Egger's test were not mathematically possible because of the methodological collection of the study designs included from single case reports to large cohorts of multiple patients.

The six domains of the ROBINS-I tool are defined as follows:

- Domain 1: Bias Due to Confounding

- Domain 2: Bias in Selection of Participants into the Study
- Domain 3: Bias in Classification of Interventions
- Domain 4: Bias Due to Missing Data
- Domain 5: Bias in Measurement of Outcomes
- Domain 6: Bias in Selection of the Reported Result
- Overall Risk of Bias

Table 4: Risk Of Bias In Non-randomised Studies of Interventions (ROBINS-I)

Study (Year)	D1: Confounding	D2: Selection	D3: Classification	D4: Missing Data	D5: Measurement	D6: Reported Result	Overall Risk
Suh et al. 2023	?	?	+	+	+	?	?
Karalikkattil et al. 2024	?	?	+	?	?	?	?
Todoki et al. 2020	?	+	+	+	+	+	?
Harris et al. 2020	?	?	+	?	+	?	?
Garnett et al. 2019	?	?	+	+	+	+	?

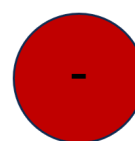
Steele et al. 2022							
Rask et al. 2021							
Moshiri et al. 2017							
Sabouni et al. 2022							
Greco et al. 2021							



Low risk concerns



Some risk concerns



High risk concerns

DISCUSSION

Clear Aligner Therapy (CAT) has come a long way from providing successful treatment outcomes for mild to moderate malocclusions only initially, to being able to adjunctively treat complex cases including orthognathic surgical approaches. To successfully achieve the orthodontic correction, clinicians need to plan in detail for an appropriate therapeutic approach based on current scientific evidence about aligners. CAT has been used in both surgical and non-surgical openbite management. The objective for conducting this systematic review was to assess retention, relapse and stability of open bite treatment by CAT. To the best of our knowledge no systematic reviews have been published on this topic and no high-quality RCTs to assess the long-term stability including various retention protocols after open bite closure using aligners have been found in the literature.

Biomechanical mechanisms and Vertical Control

One of the findings of this review is the inherent mechanical advantage of clear aligners in managing the vertical dimension by utilising a "bite-block" effect. Upper and lower aligners together create double-arch thickness of the thermoplastic material (approximately 0.75 mm per arch), and hence superior vertical control is achieved, including intrusion as well as counterclockwise autorotation of the mandible. This intrusion is critical for improving the facial profile and reducing lower facial height.^[15] However, the predictability of these types of movements remains a

clinical challenge. Intrusion is very desirable, but its accuracy varies from 30% to 51%. This discrepancy is often attributed to a lack of posterior anchorage, as most clear aligner systems rely on passive optimised attachments that may not provide sufficient grip.^[16] Resultant openbite correction in more than 50-60% scenarios is attained by extrusion of anterior teeth, and not absolute posterior intrusion. This maxillary incisor extrusion has a predictability of up to 79% in recent years depending upon attachment design.^[16]

The Role of Attachment Configuration

The interaction between the aligner materials and attachments is crucial to ensuring predictable tooth movement. Ben Mohimnd et al.^[15] pointed out that the horizontal rectangular attachments have better biomechanical properties for extrusion with a larger active surface area for the aligners. Optimised attachments designed digitally and automatically placed depending on the threshold of movement, interestingly, there were no statistically significant differences in biomechanical efficiency between optimised and conventional attachments for many movements. Specific clinical scenarios such as canine retraction in extraction cases benefit more from vertical rectangular attachments, which provide enhanced root control and minimise the unwanted distal tipping often associated with optimised retraction attachments. An additional outcome depicting vertical rectangular attachments allowing controlled root movements and minimal tipping is an insightful finding.^[15]

Stability, Relapse and Retention Protocols

Long-term overbite stability is the best way to determine success in correcting an open bite malocclusion. Open bite has a multifactorial etiology and a high relapse rate, mostly in the first year after treatment; therefore, individual and intensive retention protocols are equally important. The selection of an appropriate retention protocol should be guided by the biomechanical characteristics of the corrected malocclusion and the neuromuscular factors associated with relapse. Vacuum-formed retainers (VFRs) provide comprehensive occlusal coverage, which may help maintain the posterior vertical dimension by limiting unwanted molar eruption. Hawley retainers can be modified with posterior bite blocks to provide additional vertical control or with tongue cribs to restrict abnormal tongue positioning and function. In patients with a persistent tongue-thrust habit, a fixed bonded lingual retainer may be combined with posterior bite blocks or tongue spurs to provide both dental retention and functional control of the tongue. Such adjunctive components may be particularly relevant in maintaining anterior open-bite correction by minimising unfavourable occlusal and neuromuscular forces that could contribute to relapse.^[17] For long-term retention and to prevent relapse, vertical elastics with active clear aligner treatment can be employed which would also help prevent muscular relapse through adjunctive orofacial myofunctional therapy.^[18]

Short-term stability rates were identified across various studies by our analysis, with one study concluding the mean retention period was 2.1 ± 1.1 years. The mean change in overbite during treatment was 3.3 ± 1.5 mm; 6% of patients presented relapse at least 1 year after treatment completion.^[5] Although the initial results have been satisfactory, relapse after treatment is a crucial aspect and critical problem with the most common measurable loss of overbite in the first 12 months after active treatment. Multifactorial relapse suggests that for retention and stability, maintaining the neuromuscular balance is a must.^[5]

To reduce the risk of early relapse, a mechanical retention protocol based on evidence is crucial, but there is insufficient literature evidence to support the choice of retainer, which must be individualised based on the severity of the malocclusion at the beginning and patient-specific. Alam and Alayyash (2024)^[19] suggested that in a recent systematic review, fixed retainers should be provided to patients with a moderate to severe risk of relapse of anterior open bite, while patients with mild to moderate anterior open bite should use a removable retainer. Gu et al. (2022)^[20] conducted a prospective cohort study on the stability of three types of retainers (VFRs, Hawley retainers, and bonded retainers) and concluded that there was no statistically significant difference in stability between these three types of retainers. Gu et al. (2022)^[20] reported an overall stability rate of 89% (an 11% relapse rate) at a mean follow-up of 1.2 years. Recent clinical data

specifically evaluating CAT strongly support a dual-retention approach to maximise vertical control. Suh et al. (2022)^[5] investigated adult patients treated with non-extraction CAT and utilised a combined retention protocol consisting of fixed anterior bonded retainers paired with VFR overlays (such as Vivera™). Greco et al. (2021)^[14] reported the use of Essix retainers 12 hours per day in both arches to avoid any kind of possible re-extrusion of molars which is effective at maintaining that achieved stability. They found that after 1 year, at the end of orthodontic treatment in active retention stable conditions could be detected both in arch alignment and in vertical retention of molar positions and in smile exposure. Only a minimal 0.2 mm relapse in intrusion on the right maxillary lateral incisor can be noticed. The same condition could be detected at 3 years after the end of orthodontic treatment. However, this is a single case report, so these findings are not reliable for all patients. While the investigations by Karalikkattil et al. (2024)^[6], Todoki et al. (2020)^[7], Harris et al. (2020)^[8], Garnett et al. (2019)^[9], Steele et al. (2022)^[10], Rask et al. (2021)^[11] and Moshiri et al. (2017)^[12] primarily evaluated cephalometric changes following the active phase of treatment. They did not describe post-treatment retainer protocols and types of retainers which is a limitation of the reporting in this literature. Large cohort studies or RCTs are missing in the systematic reviews therefore, the long-term retention data are severely lacking in the current openbite literature. To address this critical gap, a case report by Greco et al. (2021)^[14] was specifically included in this review as it gives a valuable 3-year follow-up post-treatment. In this study, the authors presented an adult skeletal open bite that was successfully treated with clear aligners and adjunctive micro-osteoperforations and the corrected vertical dimension was maintained for a long-term follow-up period with no significant skeletal relapse. The long-term observation period has confirmed that relapse is more likely to occur in the first 12 months; for long-term stability is only possible if both skeletal and neuromuscular factors are carefully controlled in the active and early retention period.

Limitations and Future Perspectives

Current evidence is limited by heterogeneity in study designs, varying aligner wear protocols and absence of long-term (3+years) follow-up data. Many studies have a medium risk of bias. Quantitative meta-analysis or formal statistical tests for publication bias was not feasible because the existing literature varies significantly in structure, ranging from individual case reports to cohort studies.

Judicious use of Cone Beam Computed Tomography (CBCT) integrated with 3D Facial superimposition as future research tools, can yield more precise information regarding evaluation of skeletal or/and dental relapse and stability. Digital assessment methods allow more standardized evaluation of oral habits, treatment management and outcomes of open bite.

CONCLUSION

1. Clear aligner therapy (CAT) is a greatly effective and comparatively stable treatment modality for correction of Open Bite malocclusion in adult patient population.
2. Dual retention technique of combining fixed bonded retainers with vacuum-formed retainers (VFRs) is mandatory for post treatment stability. Strict patient compliance is needed for first 24 months post-treatment to maintain stable results. Nonetheless, patient compliance remains at the top of the list of factors deciding success and stability of achieved results.
3. Elimination of patient-specific habits like tongue thrusting and thumb sucking is equally important to maintain stable results for a longer duration. Tongue posture or interincisal tongue position is an important consideration for stability.
4. Prospective long-term studies exceeding three years follow-up are required to further validate the permanence of Clear Aligner therapy results in open bite cases.

Patient consent

Not Applicable & not required.

Ethical approval

Institutional Review Board approval was not required, as it was a systematic review of existing literature.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Acknowledgements

None

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