

Posterior open bite after clear aligner therapy: a systematic review and proposed mechanism-aware clinical classification

Stefan Abela

sa807@cam.ac.uk

University of Cambridge

Tommaso Castroflorio

University of Genoa

Marco Migliorati

University of Genoa

Research Article

Keywords: clear aligner therapy, posterior open bite, posterior disocclusion, occlusal settling, vertical control, systematic review

Posted Date: September 1st, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10646047/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background.

Posterior open bite (POB) after clear aligner therapy (CAT) is clinically recognized, but its frequency, magnitude, mechanisms and natural history remain poorly quantified. This review synthesizes the evidence and proposes a mechanism-aware millimetric clinical classification to standardize reporting and clinical stratification.

Methods.

PubMed/MEDLINE, Embase, Scopus, Web of Science and Cochrane CENTRAL were searched from inception to May 2026, supplemented by hand-searching and reference checking. Direct evidence comprised studies measuring POB or posterior disocclusion; indirect evidence comprised vertical molar change, occlusal-contact, settling and management outcomes. ROBINS-I and JBI tools were used as appropriate; meta-analysis required at least two clinically and methodologically comparable studies. After synthesis, classification thresholds were defined from direct cusp-distance data, posterior vertical-change evidence and clinical interpretability, with magnitude deliberately separated from mechanism.

Results.

Twenty-three records were retained: 19 primary clinical studies and four contextual non-primary records. One small retrospective comparative study reported visible POB at debond in 38.6% of CAT patients and 31.8% of fixed-appliance patients (prevalence ratio 1.21, 95% CI 0.59 to 2.49). Because POB was present at baseline in some participants and individual transitions were unavailable, treatment-emergent incidence could not be estimated. Two 2026 cohorts directly measured posterior cusp separation in millimetres, but heterogeneous populations, definitions and timepoints precluded pooling. Adjacent studies documented small posterior molar intrusion and reduced posterior contacts, supporting mechanistic plausibility but not a precise incidence estimate.

Conclusions.

The evidence supports a multi-mechanism model in which small posterior vertical changes, anterior geometric interference, transverse cusp disocclusion and inhibited settling may coexist. We propose four magnitude grades: sub-clinical (< 0.5 mm), mild (0.5–1.5 mm), moderate (> 1.5–3.0 mm) and severe (> 3.0 mm). The grade describes magnitude; mechanism remains diagnosis-led. This classification provides a common clinical and research language for POB and a structured basis for testing persistence, functional relevance and treatment response prospectively.

Background

Clear aligner therapy has expanded from a treatment modality for mild adult crowding to an appliance applied across most categories of dentoalveolar correction[1–3]. Its predictability for some movements has improved as the materials and software have matured[4, 5], but other movements remain less well expressed than the digital plan suggests, and the unintended consequences of treatment receive less attention than the targeted outcomes. One such consequence is loss of occlusal contact between the maxillary and mandibular posterior teeth at debond, in cases where the posterior occlusion was satisfactory at the start of treatment. Practitioners describe the finding under several names, including posterior open bite, lateral open bite, buccal segment open bite and posterior disocclusion, and treat it as a frequent though largely tolerable sequela of clear aligner therapy[6–8].

Two questions remain unresolved. The first is mechanistic. A frequently cited explanation is a bite-block hypothesis: prolonged interocclusal aligner coverage, together with occlusal loading, may contribute to posterior intrusive change[9]. Harris et al.[10]reported statistically significant maxillary and mandibular first-molar intrusion during anterior open-bite correction with clear aligners, but the magnitude was small (approximately 0.47 mm in the maxilla and 0.39 mm in the mandible), the study measured vertical molar position rather than posterior inter-arch separation, and it did not isolate passive aligner interposition as the causal factor. A potentially complementary explanation is anterior geometric interference. Incomplete planned anterior intrusion, altered incisor torque, anteroposterior correction accompanied by mandibular repositioning or posturing, or transverse crown tipping can create premature contacts and posterior disocclusion[8, 11, 12]. Distinguishing these possibilities is clinically important, but no current study establishes a dominant mechanism or mechanism-specific natural history.

The second unresolved question is quantitative. Published reports have predominantly used binary or categorical outcomes, recording posterior open bite as visible or not visible on lateral cephalogram or photograph, or as present or absent on clinical examination. Two recent digital-model cohorts now quantify posterior cusp separation in millimetres, but the field still lacks a common millimetric classification that can be applied consistently across studies and at the chairside. Without such a framework, magnitude, mechanism, natural history and treatment response cannot be compared in a reproducible way.

A third practical question is whether aligner brand or material independently modifies POB risk. Contemporary appliances differ in material properties and post-thermoforming geometry[13, 14], but whether such differences translate into different clinical post-treatment POB frequency has not been established.

The aims of this systematic review were therefore to synthesize evidence on the post-treatment frequency/prevalence and, where explicitly reported, treatment-emergent incidence of POB after clear aligner therapy; summarize proposed mechanisms and the evidence supporting them; describe direct millimetric posterior separation where available; examine natural-history and management evidence while distinguishing direct from extrapolated data; assess whether any brand-specific clinical difference

has been demonstrated; and develop a millimetric, mechanism-aware clinical classification for standardized reporting, clinical stratification and future comparative research.

Methods

Protocol and registration

The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement[15]. The protocol was registered on the Open Science Framework before final data lock and journal submission (OSF DOI/URL: 10.17605/OSF.IO/WG4AZ). Because preliminary scoping and drafting preceded registration, the OSF record states that registration occurred before the final database rerun, final eligibility confirmation, final data extraction lock and synthesis. No funding was received.

Protocol amendments and deviations

All protocol amendments were logged prospectively in the OSF record and are summarized in Supplementary Material S3. Prespecified elements included the review question, eligibility criteria, direct and indirect evidence hierarchy, primary and secondary outcomes, risk-of-bias tools, effect measures, meta-analysis feasibility criteria and certainty-assessment approach. Any change made after OSF registration, including expansion to adjacent occlusal-contact evidence or changes to outcome grouping, was dated, justified and labelled as a protocol deviation rather than silently incorporated into the review.

Review question and PICOS framework

The review question was: in adolescent or adult orthodontic patients treated with clear aligners, what is the reported frequency, magnitude, mechanism, time course and management of posterior open bite or posterior disocclusion occurring during or after treatment? The population comprised adolescents and adults treated with any commercial or in-house clear aligner system. The exposure was clear aligner therapy as the principal orthodontic appliance. Comparators were pre-treatment occlusion, fixed appliances, alternative aligner systems, or no comparator. The primary outcomes were presence of post-treatment POB and, where available, millimetric inter-arch gap at the most affected posterior tooth pair. Secondary outcomes were vertical molar change, occlusal contact area, proposed mechanism, time course of resolution, prevention and management.

Eligibility criteria

Studies were eligible if they enrolled adolescent or adult orthodontic patients treated with any commercial or in-house clear aligner system, with or without auxiliaries such as attachments, elastics or temporary anchorage devices. Eligible outcomes were deliberately separated into direct and indirect

evidence. Direct evidence comprised studies reporting posterior open bite, posterior disocclusion, buccal segment open bite or loss of posterior occlusal contact after clear aligner therapy. Indirect evidence comprised studies reporting vertical molar change, anterior open bite mechanics, transverse crown tipping, occlusal contact area, settling during retention, or management strategies relevant to post-aligner POB. Systematic and scoping reviews were not treated as primary evidence for incidence or magnitude; they were used only to identify additional studies and contextualize adjacent evidence.

Studies were excluded from the direct POB synthesis if they reported only anterior open bite correction without posterior occlusal outcomes, if the appliance was not a clear aligner system, if the article was a single case report, if full text could not be obtained after two attempts including author contact, or if the publication was not available in English or in a language for which a reliable translation was available. Studies reporting posterior open bite qualitatively but without quantification were retained for mechanism or management synthesis but were not used to estimate incidence or magnitude.

Information sources and search strategy

Electronic searches were conducted in PubMed/MEDLINE, Embase (Elsevier), Scopus, Web of Science (Clarivate) and the Cochrane Central Register of Controlled Trials from database inception to May 2026. Hand-searches were performed in major orthodontic journals, and reference lists of included studies and relevant reviews were screened. Grey literature was searched to identify clinical commentary and management approaches but was not used to estimate incidence. The complete database-specific search strategies are provided in Supplementary Material S1; the PRISMA checklist is provided separately in Supplementary Material S2.

A targeted manual verification of the available evidence was performed in June 2026 to ensure that the discussion captured adjacent studies on occlusal contacts, Objective Grading System occlusal-contact deductions, molar intrusion and posterior open-bite management that might not report POB as a binary outcome. These records were used for contextual triangulation or mechanistic plausibility and not to estimate POB frequency. Xiao et al.[16]and Zhuo et al.[17]each reported direct millimetric posterior-disocclusion outcomes and were retained among the primary clinical studies; because their definitions, populations and timepoints differed, their data were not considered directly comparable and were not pooled.

A representative MEDLINE search string combined three concept blocks: (i) "clear aligner*" OR Invisalign OR ClearCorrect OR Spark OR "thermoplastic aligner*"; (ii) "posterior open bite" OR "lateral open bite" OR "buccal open bite" OR "posterior disocclusion" OR "bite block effect" OR "molar intrusion" OR "occlusal settling"; and (iii) humans[MeSH]. The full set of search strings, with database-specific syntax, is provided in Supplementary Material S1.

Study selection

Records were imported into Rayyan software (Rayyan, Cambridge, MA, USA) after deduplication. Two reviewers independently screened titles and abstracts, with conflicts resolved by discussion or by a third reviewer. The same two reviewers performed full-text screening against the eligibility criteria. Inter-rater agreement was quantified by Cohen kappa at both stages. Agreement was substantial at title and abstract screening (kappa 0.81) and at full-text screening (kappa 0.86).

Data extraction

Data were extracted into a pre-piloted spreadsheet by one reviewer and verified by a second. Extracted fields included study design, country, sample size, age, sex, malocclusion type, aligner system, attachment protocol, planned vertical molar movement, treatment duration, POB definition, assessment method, post-treatment prevalence/frequency, treatment-emergent incidence when explicitly derivable, millimetric gap where available, molar vertical change, time to onset, follow-up duration, resolution during retention, and management approach. When multiple reports appeared to use overlapping datasets, the most complete or most recent dataset was retained for quantitative description to avoid double counting.

When outcome data were unclear, the extracted value was recorded as reported and no numerical transformation was performed unless the required statistic could be calculated directly from published counts, means, standard deviations or confidence intervals. Authors of otherwise eligible articles with missing direct POB-gap or occlusal-contact data were contacted, and unanswered requests were documented in the extraction file.

Outcome hierarchy

The prespecified primary outcome was post-treatment POB measured as a continuous millimetric inter-arch gap at the most affected posterior tooth pair in maximum intercuspation. No included cohort reported this exact outcome in a standardized way; the closest available direct outcomes were binary visible POB at debond and, in two cohorts, posterior cusp separation measured in millimetres on digital models. Secondary outcomes were first-molar vertical change in millimetres, occlusal contact area, spontaneous resolution during retention, and reported management. Evidence was therefore synthesized by outcome proximity: direct POB evidence first, then indirect biomechanical and retention evidence.

Risk of bias assessment

Comparative observational and cohort studies were appraised with ROBINS-I[18], case series with the Joanna Briggs Institute critical appraisal checklist[19], and existing reviews with AMSTAR 2[20] when used for contextual interpretation. Risk of bias was assessed independently by two reviewers, with disagreements resolved by consensus. The overall certainty of evidence for each outcome domain was

judged using GRADE principles, considering risk of bias, inconsistency, indirectness, imprecision and publication/reporting bias.

Methodological handling of recurrent measurement and design limitations

Three recurrent limitations were handled explicitly rather than treated as generic weaknesses. First, lateral cephalometric diagnosis was not considered equivalent to a three-dimensional clinical measurement of posterior open bite. Because right and left posterior segments are superimposed and unilateral disocclusion cannot be localized or quantified reliably, cephalometric visible POB was retained only as the nearest available direct surrogate and was downgraded for indirectness. Whenever digital occlusal-contact data or intraoral-scan-based outcomes were available, they were interpreted as closer to the clinical construct than two-dimensional cephalometric visibility.

Second, single-provider studies were not automatically dismissed, because they may reduce variability in diagnosis, digital setup, staging and finishing protocols. However, their estimates were downgraded for limited external validity and were not generalized to routine practice without qualification. The appropriate design solution is a multicentre cohort with centre and operator recorded prospectively and analysed through mixed-effects models, using operator or centre as a random effect and provider experience as a covariate.

Third, individualized treatment planning was treated as a potential source of clinical confounding rather than simple noise. Planned molar intrusion or extrusion, anterior intrusion or retraction, anteroposterior correction, transverse expansion, use of attachments, inter-arch elastics, IPR, number of refinements, retention protocol and wear regimen should be extracted and reported whenever available. When these variables were absent or incompletely reported, certainty was downgraded for confounding and indirectness. Future studies should predefine these variables as covariates or subgroup factors rather than pooling heterogeneous virtual setup strategies as though they represented a single intervention.

Certainty assessment and summary of findings

For each outcome domain, certainty of evidence was judged using GRADE principles and summarized as high, moderate, low or very low. Downgrading was considered for study limitations, inconsistency, indirectness, imprecision and publication bias. Because most outcomes were unsuitable for pooling, certainty judgements emphasized outcome directness and measurement validity rather than pooled precision alone. The outcome-specific certainty assessment is presented in Table 7.

Assessment of reporting biases

Risk of bias due to missing results was planned to be assessed formally only when at least ten studies contributed to a comparable synthesis, using funnel-plot asymmetry and small-study effects as appropriate. Because no synthesis reached this threshold, reporting bias was assessed qualitatively by comparing registered or stated study aims, reported outcomes, availability of posterior occlusal-contact data and whether negative or null posterior outcomes were selectively absent.

Missing data and unit-of-analysis considerations

The patient was the unit of analysis for patient-level POB prevalence/frequency, treatment-emergent incidence when available, and molar vertical-change outcomes. Tooth-, cusp- or contact-level outcomes were retained at their reported unit and were not pooled with patient-level POB outcomes; within-patient clustering was considered when interpreting site-level data. Missing outcome data were not imputed. Studies with incomplete but clinically relevant posterior-occlusion information were retained for qualitative synthesis and downgraded for indirectness or reporting limitations.

Effect measures

For binary outcomes, prevalence ratios or prevalence differences were planned for cross-sectional post-treatment presence, whereas risk ratios or risk differences were reserved for true treatment-emergent incidence when individual transition data were available. For single-arm proportions, Wilson 95% confidence intervals were planned. For continuous millimetric outcomes, planned measures were mean differences with 95% confidence intervals; standardized mean differences were reserved for comparable constructs measured on different scales. Digital occlusal-contact outcomes were extracted as reported and were not converted into POB prevalence or incidence.

Synthesis

A high degree of heterogeneity was anticipated and confirmed across studies in outcome definition, measurement method, follow-up interval and reporting completeness. Meta-analysis was prespecified only when at least two clinically comparable studies reported the same direct outcome using compatible definitions and time points. Random-effects models were planned for pooled analyses because clinical heterogeneity across operators, aligner systems, malocclusion types and treatment plans was expected. Heterogeneity would have been explored using clinical subgrouping by outcome definition, measurement method, aligner system, planned vertical movement and retention protocol; however, these analyses were not performed because no outcome domain met the minimum compatibility requirement for pooling.

Development of the proposed classification

Following evidence synthesis, the authors developed a four-tier descriptive classification using three explicit anchors: (1) direct millimetric posterior cusp-separation data from the included cohorts; (2) the magnitude and direction of posterior vertical tooth changes reported in mechanistic studies; and (3) the need for clinically interpretable, mutually exclusive gap strata that can be applied reproducibly in clinical and research settings. Thresholds were agreed by author consensus as < 0.5 mm, 0.5–1.5 mm, > 1.5–3.0 mm and > 3.0 mm. Because no cohort linked gap magnitude to spontaneous resolution or treatment need, the cut-points were not statistically outcome-derived. The grade was deliberately defined by magnitude alone, while mechanistic attribution and management were kept as parallel dimensions to avoid circularity. This creates a descriptive clinical taxonomy that can be used now for standardized reporting while its prognostic performance is quantified in longitudinal studies.

Results

Search and selection

The database search yielded 1072 records, with a further 24 records identified through hand-searching and grey literature, for a total of 1096 records. After removal of 419 duplicates, 677 records were screened at title and abstract level, of which 592 were excluded. Full text was sought for 85 records and assessed for 78 after seven could not be retrieved. After full-text screening, 55 records were excluded, with the primary reason for each exclusion reported in Supplementary Table S4. Twenty-three records were retained in the qualitative evidence map: 19 primary clinical studies, including Xiao et al.[16] and Zhuo et al.[17], and four contextual non-primary records (three review-level sources and one clinical management article). The PRISMA 2020 flow diagram is presented in Fig. 1.

Characteristics of included studies

The 19 primary clinical studies were dominated by retrospective observational designs, with two prospective cohorts and one three-patient case series. Four additional non-primary records were retained only for contextual synthesis: three review-level sources and the clinical management article by Akinwale-Quansah and Singh[21]. Invisalign® accounted for most of the direct clinical evidence. Adjacent occlusal-contact and treatment-outcome studies were used to establish whether posterior contact deficiency is a reproducible construct, not to increase or validate a POB prevalence estimate.

Table 1
Characteristics of the 19 primary clinical studies included in the qualitative synthesis.

Author, year [ref]	Design	n (CAT)	Outcome measured	Key finding
Rask et al., 2021[22]	Retrospective cephalometric	44	Visible POB (yes/no), molar height	Post-treatment visible POB was 38.6% versus 9.1% at baseline. These aggregate counts describe prevalence at each timepoint; treatment-emergent incidence cannot be derived without individual transition data.
Talens-Cogollos et al., 2022[23]	Retrospective cephalometric	58	Unplanned molar intrusion (mm)	Unplanned molar intrusion in 74.2%. Maxillary first molar 0.98 ± 0.54 mm, mandibular first molar 0.84 ± 0.29 mm.
Moshiri et al., 2017[24]	Retrospective cephalometric (AOB)	30	Molar position changes	Mandibular molar intrusion 0.6 mm contributed to AOB closure by counterclockwise rotation.
Garnett et al., 2019[25]	Retrospective comparative	30	Vertical dimension changes	No significant difference between aligners and fixed appliances in AOB correction or vertical control.
Khosravi et al., 2017[26]	Retrospective	120	Overbite change	Mean overbite reduction 1.5 mm; relative intrusion of incisors rather than true posterior intrusion.
Lo-Cao et al., 2025[27]	Retrospective CBCT	15	Molar intrusion (CBCT)	Invisalign® did not express planned intrusion; SIS achieved approximately 2.1 to 3.0 mm greater molar intrusion than aligners.
Suh et al., 2022[28]	Retrospective	69	AOB correction mechanism	AOB closure dominated by incisor extrusion; posterior intrusion limited.
Harris et al., 2020[10]	Retrospective cephalometric	45	AOB closure mechanism	Small first-molar intrusion was measured during anterior open-bite correction (0.47 ± 0.59 mm maxillary; 0.39 ± 0.76 mm mandibular). The study did not isolate passive bite-block causation or measure residual POB gap.
Pinho et al., 2025[29]	Longitudinal pilot cohort	42	Occlusal contact, masticatory performance, TMD	CAT temporarily reduced occlusal contact area but did not impair chewing efficiency or trigger TMD signs.

Author, year [ref]	Design	n (CAT)	Outcome measured	Key finding
Djeu et al., 2005[30]	Retrospective comparative outcome study	48 CAT / 48 fixed	ABO OGS domains	Invisalign cases had worse OGS performance than fixed appliances, including occlusal contacts, occlusal relationships and overjet; indirect evidence for less ideal posterior occlusal finishing.
Buschang et al., 2015[31]	Prospective within-subject model comparison	27	Predicted vs actual OGS occlusion	Actual post-treatment models had more OGS deductions than ClinCheck predictions, including occlusal contacts and occlusal relationships; supports mismatch between planned and achieved occlusion.
Bowman et al., 2023[32]	Retrospective digital model study	33	Predicted vs achieved occlusal contacts	Achieved posterior occlusal contacts after Invisalign were significantly lower than predicted and lower than pretreatment posterior contacts.
Frenkel et al., 2024[33]	Retrospective digital model study	45	Occlusal contact categories	Digital occlusal-contact analysis supports posterior contact deficiency as a measurable adjacent outcome, but it is not a standardized POB prevalence/incidence endpoint.
Marcelino et al., 2023[34]	Longitudinal cohort	82	Occlusal contacts during aligner treatment and retention	Tracked occlusal-contact changes through treatment and retention; relevant to continuous occlusal coverage and settling, but not a direct POB prevalence endpoint.
Oliva et al., 2026[35]	Retrospective pilot comparative study	12 CAT / 12 fixed	3D occlusal contact surface and distribution	Fixed appliances showed higher tight occlusal-contact surface values; clear aligners showed a more anterior contact distribution. Supports CAT-specific posterior contact concerns, but as pilot indirect evidence.
Sabouni et al., 2022[8]	Case series	3	Open-bite mechanics and management with clear aligner or hybrid mechanics	Three anterior open-bite cases treated with clear-aligner-based or adjunctive mechanics; provides mechanistic and management context but no POB incidence or continuous posterior-gap outcome.
Patterson et al., 2021[36]	Retrospective cohort	80	ABO-OGS outcomes; AP and vertical	Adult Class I and Class II Invisalign patients showed limited expression of AP and

Author, year [ref]	Design	n (CAT)	Outcome measured	Key finding
			measurements; posterior open bite/refinement issues	overbite correction; occlusal-contact scores worsened and posterior open bite was noted as a reason for additional refinements.
Zhuo et al., 2026[17]	Retrospective digital-model and cephalometric	65 (34 mild, 31 moderate to severe crowding)	Posterior functional cusp distance (mm); cephalometric risk factors	Premolar-extraction CAT cases; posterior functional cusp distance increased significantly, greatest at the first molars in mild crowding (mesiobuccal 1.64 mm, distobuccal 1.48 mm); smaller ANB angle and greater maxillary incisor proclination were associated with greater posterior disocclusion. Provides direct millimetric posterior-gap data.
Xiao et al., 2026[16]	Prospective clinical cohort	52 (172 molar sites)	Posterior open bite (mm) at molar cusps; settling-elastic management	POB defined as a posterior cusp distance greater than 0 mm after refinement; vertical settling elastics significantly improved buccal-cusp occlusal contacts (mean achieved buccal-cusp extrusion approximately 1.65 mm with elastics versus 0.23 mm without in the pilot sample); substantial planned overcorrection required. Provides direct millimetric posterior cusp data and prospective management evidence.

AOB, anterior open bite; CAT, clear aligner therapy; CBCT, cone-beam computed tomography; POB, posterior open bite; SIS, Sydney Intrusion Spring; TMD, temporomandibular disorder.

Post-treatment frequency/prevalence

The only direct comparative dataset reporting visible post-treatment POB was the retrospective cephalometric study by Rask and colleagues[22]. They examined 44 adult Invisalign® patients and 22 adult fixed-appliance patients treated to a Class I non-extraction finish without planned molar intrusion or extrusion. Visible POB was present at baseline in 4 of 44 aligner patients (9.1%) and 1 of 22 fixed-appliance patients (4.5%), and at debond in 17 of 44 aligner patients (38.6%) and 7 of 22 fixed-appliance patients (31.8%). The ratio of the post-treatment prevalences was 1.21 (95% CI 0.59 to 2.49), with substantial imprecision and no statistically demonstrable difference between groups. Because POB was already present at baseline and individual patient transitions from absent to present were not reported, these aggregate counts do not permit estimation of treatment-emergent incidence. The 38.6% value

should therefore be interpreted only as post-treatment prevalence of visible cephalometric POB in this small adult aligner cohort.

Two further cohorts published in 2026 measured posterior disocclusion directly in millimetres rather than as a binary outcome and were retained as direct evidence on magnitude. Zhuo et al.[17] retrospectively analysed 65 Invisalign® patients treated after four first-premolar extractions and reported the greatest mean pre-to-post increase at the first molars (approximately 1.64 mm at the mesiobuccal cusp and 1.48 mm at the distobuccal cusp in the mild-crowding subgroup); smaller ANB angle and greater maxillary incisor proclination were reported as risk factors. Xiao et al.[16] prospectively studied 52 Invisalign® patients with POB after refinement, assessing 172 molar sites; vertical settling elastics improved buccal-cusp contacts, with mean achieved buccal-cusp extrusion of approximately 1.65 mm under elastic traction versus 0.23 mm without elastics in the pilot sample. These studies show that posterior disocclusion can be quantified in millimetres, but their site definitions, populations and timepoints differ and neither reports the prespecified single most affected posterior tooth-pair endpoint. They therefore inform magnitude but not a pooled prevalence or treatment-emergent incidence estimate.

Talens-Cogollos and colleagues reported the only quantitative cohort study of unplanned molar intrusion specifically, in 58 adults treated with Invisalign® SmartTrack®. They documented unplanned molar intrusion in 74.2% of patients, with mean values of 0.98 mm at the maxillary first molar and 0.84 mm at the mandibular first molar on lateral cephalogram. This study measured molar displacement rather than the inter-arch posterior gap; it should therefore be interpreted as indirect evidence for one possible mechanism, not as a direct measurement of POB severity.

Adjacent occlusal-outcome studies provide evidence that posterior contact deficiency can occur after aligner therapy. Djeu et al.[30]found less favourable Invisalign performance than fixed appliances in ABO Objective Grading System domains including occlusal contacts and relationships; Buschang et al.[31]reported more OGS deductions in achieved than predicted aligner occlusion; and Patterson et al.[36]described posterior open-bite/refinement problems in adult Class II aligner treatment. These outcomes are clinically relevant but are not equivalent to a prespecified POB diagnosis and cannot be used to estimate its prevalence or incidence.

More recent digital occlusal-contact studies provide convergent evidence for the broader construct of posterior contact deficiency. Bowman et al.[32]reported fewer achieved posterior contacts than predicted and pretreatment contacts; Frenkel et al.[33]quantified contact changes on digital models; Marcelino et al.[34]followed occlusal contacts through treatment and retention; and Oliva et al.[35]found higher tight-contact surface values after fixed appliances and a more anterior contact distribution after clear aligner therapy. Systematic reviews by Ke et al.[37]and Papageorgiou et al.[38]also reported less favourable occlusal or overall treatment-outcome measures for aligners in some comparisons. These findings support the clinical relevance of posterior contact deficiency but do not validate, refine or increase confidence in the numerical 38.6% post-treatment POB prevalence reported by Rask et al.[22].

No included study reported post-treatment POB prevalence or treatment-emergent incidence by aligner brand in a controlled head-to-head comparison. Brand-specific clinical risk therefore cannot be estimated.

Quantitative synthesis and meta-analysis feasibility

A formal meta-analysis was not conducted because the minimum evidentiary requirement, at least two comparable studies reporting the same direct posterior open bite (POB) outcome using compatible definitions and timepoints, was not satisfied. The primary planned outcome, defined as the millimetric inter-arch gap at the single most affected posterior tooth pair, was not reported in a standardized form by any included cohort. Binary visible POB at debond was documented in only one comparative study. Two further cohorts reported posterior cusp separation in millimetres, but their outcome definitions (post-refinement cusp distance with elastic management versus pre-to-post functional cusp-distance change), populations (refinement-stage non-extraction versus premolar-extraction) and measurement timepoints differed sufficiently that pooling would be statistically inappropriate. Consequently, the quantitative synthesis is restricted to single-study descriptive estimates and should not be interpreted as pooled evidence.

The additional occlusal-contact studies were not pooled with Rask et al. because they measured different constructs: ABO-OGS occlusal-contact deductions[30, 31], predicted-versus-achieved posterior contact area[32], digital contact categories or contact distribution[33–35], or global treatment-outcome differences in systematic reviews[37, 38]. Pooling these outcomes with binary visible POB would be statistically inappropriate and clinically misleading. Their role is evidentiary triangulation of the posterior-contact construct, not numerical corroboration of POB prevalence.

Failure to identify a poolable POB endpoint should not be interpreted as absence of quantitative evidence for posterior vertical change during aligner therapy. Harris et al.[10] reported mean first-molar intrusion of 0.47 mm in the maxilla and 0.39 mm in the mandible during clear-aligner treatment of anterior open bite. This is mechanistically relevant tooth-position evidence, but it neither measures post-treatment posterior inter-arch separation nor isolates passive bite-block loading as the cause of the observed intrusion.

Table 2
Feasibility of quantitative synthesis by outcome.

Outcome domain	Studies with compatible data	Planned effect measure	Meta-analysis decision	Reason
Millimetric POB gap at debond	2 (incompatible)	Mean difference or pooled mean	Not performed	Two cohorts reported posterior cusp separation in millimetres, but with incompatible definitions, populations and timepoints; no standardized inter-arch gap at the single most affected tooth pair was reported, so pooling was inappropriate.
Binary visible POB at debond	1 direct comparative study	Post-treatment prevalence ratio / prevalence difference	Not performed	Only one eligible direct comparative study; post-treatment prevalence ratio 1.21 (95% CI 0.59 to 2.49). Treatment-emergent incidence was not derivable from aggregate counts because POB was present at baseline.
Unplanned molar intrusion	Two principal indirect cephalometric datasets plus several adjacent AOB studies	Mean difference / pooled mean	Not performed	Not pooled because studies measured vertical molar displacement in different clinical contexts and did not directly measure residual POB gap or isolate passive bite-block causation.
Spontaneous resolution during retention	0 direct post-aligner cohorts	Time-to-resolution or pooled proportion resolved	Not performed	Evidence derived from adjacent retention/settling literature rather than post-aligner POB cohorts.

Proposed mechanisms

Across the included literature, four mechanistic hypotheses for post-aligner posterior open bite recur and are summarized in Table 3. Evidential support differs across mechanisms, and none has been shown to be dominant by a study measuring the competing mechanisms concurrently.

Table 3
Proposed mechanisms of posterior open bite during or after clear aligner therapy.

Mechanism	Description	Supporting evidence	Counter-evidence or limit
Anterior geometric interference	Premature anterior contact (from incomplete intrusion, retroclination, or AP correction) wedges posterior segments apart through condylar lever arm	International expert consensus[7, 9]; biomechanics review[6]; clinical case series[8, 11]; mechanistic plausibility from incisor torque expression data[39]	No cohort study has measured anterior interference magnitude concurrently with posterior gap
Posterior intrusive change / bite-block hypothesis	Posterior intrusive change may be associated with prolonged occlusal coverage/loading during aligner wear.	Unplanned molar intrusion reported by Talens-Cogollos et al. [23]; small first-molar intrusion during CAT of anterior open bite reported by Harris et al. [10].	Neither study isolates passive aligner interposition as the causal mechanism; both measured tooth position rather than residual POB gap.
Unwanted buccal crown tipping during expansion	Transverse correction expressed partly as crown tipping could alter functional cusp relationships and contribute to disocclusion.	CBCT and clinical studies of expansion show consistent crown tipping in posterior segments[40, 41]; finite-element modelling supports tipping pattern[42]	Evidence is indirect: cited expansion studies did not measure POB gap concurrently.
Insufficient settling under continuous occlusal coverage	Full-coverage trays or retainers may reduce the opportunity for physiological posterior settling.	Adjacent retention literature reports greater posterior contact gain with some non-full-coverage designs[43–46].	Evidence derives largely from post-fixed-appliance retention and does not establish the natural history of post-aligner POB.

Anterior geometric interference

Anterior geometric interference is a plausible and clinically important explanation advanced in expert consensus statements and contemporary biomechanics literature. Contributory anterior changes may include incomplete planned intrusion, altered incisor torque, or anteroposterior correction accompanied by mandibular repositioning or posturing; each could create a premature contact and posterior mandibular rotation. However, no cohort has measured anterior interference magnitude concurrently with posterior gap, so this mechanism remains a testable hypothesis rather than a proven dominant cause.

Bite-block effect and unplanned posterior intrusion

Posterior molar intrusion has been documented during clear aligner therapy, but the causal contribution of passive aligner interposition remains uncertain. Talens-Cogollos et al.[23] reported unplanned first-molar intrusion of approximately 0.98 mm in the maxilla and 0.84 mm in the mandible, and Harris et al. [10] reported 0.47 ± 0.59 mm and 0.39 ± 0.76 mm, respectively, during anterior open-bite treatment. These studies establish that small posterior intrusive changes can occur; they do not isolate a bite-block mechanism from planned mechanics, occlusal loading, treatment design or other confounding factors, and neither directly measured residual posterior POB gap.

Accordingly, the available vertical-tooth-position evidence should be used as mechanistic context rather than as a mechanism-specific severity threshold. Small molar intrusion may contribute to posterior disocclusion, but moderate or severe gaps cannot be attributed to, or excluded from, a bite-block mechanism on magnitude alone. Larger or persistent gaps warrant assessment of anterior contacts, transverse cusp relationships, molar position and mandibular posture.

Unwanted buccal crown tipping during expansion

Aligner-driven transverse correction can include buccal crown tipping rather than pure bodily translation[40, 41], and finite-element modelling supports non-uniform crown/root displacement during expansion[42]. Such tipping could alter functional cusp relationships and contribute to posterior disocclusion even when vertical molar position changes little. However, the cited expansion studies did not measure POB gap concurrently, so this remains an indirect mechanistic inference.

Insufficient settling under continuous occlusal coverage

Continuous occlusal coverage by aligner trays and full-coverage thermoplastic retainers may reduce the opportunity for physiological posterior settling. The adjacent retention literature reports greater posterior contact gain with retainers that leave more posterior occlusal surfaces uncovered than with clear overlay retainers in some settings[43–46]. These data are relevant to the settling hypothesis but derive largely from post-fixed-appliance retention and should not be interpreted as direct evidence of the natural history of post-aligner POB.

Quantitative magnitude of posterior open bite and comparison with aligner thickness

Direct millimetric measurement of posterior disocclusion has only recently entered the literature identified by this review. Zhuo et al.[17] reported pre-to-post functional cusp-distance increases concentrated at the first molars, and Xiao et al.[16] quantified post-refinement molar cusp separation and response to vertical settling elastics. These cohorts provide an initial numerical reference in the low-single-millimetre range, but their definitions, populations, units of analysis and timepoints differ. They do not validate the proposed grade boundaries and do not yet provide a standardized measurement of the inter-arch gap at the single most affected posterior tooth pair.

Aligner thickness remains relevant as mechanistic context during appliance wear. Palone et al.[47]and Bucci et al.[48] demonstrated that thermoforming and intraoral use alter effective aligner thickness, including in occlusal regions. However, the physical thickness present while the trays are in the mouth should not be interpreted as a one-to-one numerical predictor of residual POB after the aligners are removed. Persistent post-treatment disocclusion reflects tooth-position and occlusal relationships, not simple plastic interposition.

Two conclusions are defensible from the quantitative evidence. First, small posterior intrusive changes are measurable during CAT, approximately sub-millimetric to 1 mm in the principal cephalometric cohorts[10, 23]. Second, direct cusp-separation studies demonstrate that larger posterior discrepancies can be measured[16, 17]. The current literature does not define an evidence-based gap threshold that distinguishes one mechanism from another.

Gap magnitude should therefore be used as a standardized descriptive variable and as a trigger for diagnostic reassessment, not as a mechanistic diagnosis. Persistent or larger gaps should prompt evaluation of anterior contacts, transverse cusp relationships, posterior tooth position and mandibular posture before a management strategy is selected.

Brand-specific evidence

No included study provided a controlled head-to-head comparison of post-treatment POB prevalence or treatment-emergent incidence between commercial aligner systems. Most direct clinical evidence identified in this review involved Invisalign®, which limits external applicability to other systems but does not imply higher or lower brand-specific risk.

Material composition, stiffness, stress relaxation and post-thermoforming geometry differ among aligner products[13, 14, 47]. These in-vitro or material-level differences are mechanistically relevant, but no included clinical study linked a specific material property to a standardized POB endpoint. They therefore cannot be used to infer comparative clinical risk.

Likewise, inter-product differences in effective occlusal thickness after thermoforming[47]do not establish differences in residual POB after tray removal. A clinical association between aligner thickness and post-treatment posterior disocclusion has not been demonstrated.

Refinement or conversion-to-fixed-appliance data from single-system cohorts[49]are not valid proxies for cross-brand POB risk and should not be interpreted as evidence that different systems perform similarly or differently for this specific outcome.

The available evidence therefore does not support a brand-specific POB risk estimate. A valid comparison would require a prospective multicentre design with a standardized millimetric endpoint and adjustment for operator, malocclusion, treatment plan, auxiliaries and case complexity.

Table 4
Aligner-system evidence relevant to posterior open bite.

System/category	Clinical evidence relevant to POB	Standardized POB endpoint?	Head-to-head POB comparison?	Interpretation
Invisalign-based CAT	Most direct POB studies and much of the adjacent occlusal evidence identified in this review	Partial; definitions remain heterogeneous	No	Provides most available evidence but cannot establish brand-specific risk.
Other commercial thermoformed aligner systems	No eligible comparative clinical POB cohort with a standardized endpoint identified	No	No	POB risk cannot be estimated from the available evidence.
Directly 3D-printed / in-house systems	No eligible clinical POB cohort with a standardized endpoint identified	No	No	POB risk cannot be estimated from the available evidence.

No included study provided a head-to-head clinical estimate of POB risk between commercial aligner systems. Material differences may be mechanistically relevant, but their clinical relationship with post-treatment POB remains untested. POB, posterior open bite.

Proposed mechanism-aware clinical classification

The classification in Table 5 is the principal translational output of this review. It converts fragmented evidence into a common millimetric language while deliberately separating what can be measured (gap magnitude) from what must be diagnosed (mechanism). The four mutually exclusive strata - sub-clinical, mild, moderate and severe - distinguish trace separation from the low-single-millimetre disocclusion documented in direct digital-model cohorts and from larger gaps that are increasingly difficult to reconcile with small posterior vertical changes alone. The grade should therefore be reported together with side, tooth pair, measurement method and suspected mechanism. This structure makes the classification directly usable for clinical communication and research without allowing magnitude alone to dictate aetiology or treatment.

Table 5

Proposed mechanism-aware millimetric clinical classification of post-aligner posterior open bite.

Grade	Gap (mm)	Mechanism-aware interpretation	Natural-history evidence	Initial clinical action
Sub-clinical	< 0.5	Trace separation; first confirm reproducibility and exclude registration or occlusal variability.	No grade-specific longitudinal data.	Document if reproducible; observation is reasonable when asymptomatic and stable.
Mild (Grade I)	0.5–1.5	Compatible with small posterior vertical change, incomplete settling, anterior interference, transverse cusp disocclusion, or combinations; magnitude alone does not assign cause.	Spontaneous settling is biologically plausible, but probability and timing are unknown.	Document side, tooth pair and contacts; assess anterior/transverse contributors; consider supervised settling when retention can be maintained.
Moderate (Grade II)	> 1.5–3.0	Magnitude makes isolated small posterior intrusion a less complete explanation; actively investigate anterior interference, transverse relationships, tooth-position errors and mandibular posture.	No grade-specific prognosis is available.	Early diagnostic reassessment; targeted refinement and/or vertical elastics according to the diagnosed mechanism.
Severe (Grade III)	> 3.0	Large separation warrants a multifactor diagnostic work-up; isolated small posterior vertical change is unlikely to explain the entire gap.	No grade-specific prognosis is available.	Prompt individualized correction; consider skeletal anchorage only for a defined movement objective.

Time course of spontaneous resolution

Direct longitudinal data on the resolution of post-aligner POB are lacking. No included study tracked a standardized millimetric posterior gap from debond through retention. The literature therefore does not support grade-specific probabilities or fixed time-to-resolution claims.

Adjacent post-orthodontic retention studies show that occlusal contacts can change during the first months after debond and that retainer design can influence posterior contact development[43–46]. Because these studies largely concern patients debonded from fixed appliances and do not start from a standardized post-aligner POB diagnosis, their timelines should not be transferred directly to post-aligner POB prognosis.

Dincer and Isik Aslan[46] provide adjacent evidence that full-coverage thermoplastic retention can influence occlusal settling; this study is not CAT-specific. Pinho et al.[29] is directly relevant to CAT and

observed recovery of occlusal contact area during retention in a longitudinal cohort, but it did not stratify or track a standardized millimetric POB endpoint. Together, these studies justify longitudinal observation, not a specific expected closure time.

Because direct grade-specific natural-history data are not yet available, Table 6 is presented as a longitudinal assessment schedule rather than as a prediction of spontaneous closure. This distinction is deliberate: the classification can standardize baseline severity now, while serial observation can determine whether grade predicts persistence, functional relevance or treatment need. In clinical care, reassessment should remain individualized according to symptoms, reproducibility of the gap, diagnosed occlusal interference and retention requirements.

Table 6

Suggested longitudinal assessment windows after diagnosis of post-aligner posterior open bite.

Grade	0 to 4 weeks	1 to 3 months	3 to 6 months	6 to 12 months
Sub-clinical	Confirm measurement and symptoms.	Reassess only if persistent or clinically relevant.	Record persistence/resolution if followed.	Final status if still under observation.
Mild (Grade I)	Document gap, contacts and possible interference.	Primary settling/reassessment window; no expected closure proportion can be assigned.	Record persistence, intervention and function.	Long-term status if unresolved.
Moderate (Grade II)	Early diagnostic reassessment and mechanism documentation.	Record need for and response to active management.	Persistence/response endpoint.	Long-term occlusal and functional outcome.
Severe (Grade III)	Prompt diagnostic reassessment; management should not be delayed solely to test spontaneous settling.	Response-to-treatment endpoint.	Persistence and functional outcome.	Long-term occlusal and functional outcome.

These timepoints operationalize standardized follow-up without embedding unsupported assumptions about the probability or timing of spontaneous resolution.

Prevention and management

Prevention recommendations should remain diagnosis- and plan-specific rather than be driven by numerical rules unsupported by outcome data. Practical measures include avoiding digital setups that create or exaggerate anterior interferences, preserving case-appropriate overjet and anterior torque, controlling transverse crown tipping and root torque, reviewing planned vertical movements and inter-

arch elastics, and monitoring posterior contacts during the later stages of treatment[4–9]. When posterior contact is borderline at debond, any retention modification intended to permit settling should be individualized and supervised so that posterior settling is not pursued at the expense of relapse[43, 45, 46].

Reported management approaches include selective aligner or retainer cut-back in clinical management literature[6, 21], short vertical elastics or buccal-button mechanics (with prospective support for vertical settling elastics in a selected post-refinement cohort[16]), and refinement directed at a documented anterior or transverse interference[7, 9, 21]. Skeletal anchorage evidence is extrapolated from true molar intrusion in other open-bite contexts[27, 50] and should not be presented as POB-specific comparative evidence. No comparative effectiveness trial establishes a preferred strategy; management should follow the diagnosed mechanism and retention requirements.

Functional consequences and TMD

The evidence base on the functional consequences of post-aligner posterior open bite specifically is small. Pinho and colleagues[29] reported a longitudinal pilot cohort of 42 patients undergoing clear aligner therapy in whom occlusal contact area was reduced during treatment but in whom chewing efficiency and TMD signs were preserved, with the occlusal contact area recovering during retention. The broader systematic review evidence on the temporomandibular impact of clear aligner therapy reports mild and self-limiting masticatory soreness during early aligner wear but no consistent association with persistent TMD[51, 52]. A separate body of evidence on masticatory performance after fixed orthodontic treatment shows that post-treatment masticatory performance is initially lower than that of controls, with a time-dependent recovery during the first year of retention that approaches but does not match population norms[53]. Whether the trajectory is identical in patients with persistent moderate or severe post-aligner posterior open bite has not been studied; this is an evidence gap of practical clinical importance and is identified below.

Risk of bias and certainty of evidence

Across the included comparative literature, risk of bias was generally moderate to serious. Common limitations were retrospective design, non-randomized treatment allocation, small samples, lack of blinded outcome assessment, heterogeneous outcome definitions and reliance on two-dimensional cephalometric assessment for a three-dimensional occlusal phenomenon. Case-based evidence was useful for mechanism and management but not for estimating post-treatment prevalence or treatment-emergent incidence. Certainty was downgraded for indirectness and imprecision across all outcome domains.

Reporting biases

Formal funnel-plot or regression-based assessment of publication bias was not possible because no direct POB outcome included ten or more comparable studies. Reporting bias remains plausible because posterior occlusion was often reported as an OGS subdomain, digital contact variable or qualitative

clinical observation rather than as a prespecified adverse outcome. This concern contributed to downgrading certainty for post-treatment frequency, mechanism and management.

Study- and record-level appraisal details are provided in Supplementary Material S5. ROBINS-I, JBI and AMSTAR 2 judgements were verified against the final evidence map after the post-registration search rerun. Outcome-level certainty and outcome directness, rather than study design alone, determined how strongly each source contributed to the proposed framework.

These three limitations affected certainty in different ways. Cephalometric assessment primarily reduced outcome directness; single-provider sampling primarily reduced applicability; and treatment-plan heterogeneity primarily increased risk of confounding. Separating these domains is important because they require different solutions: three-dimensional endpoint measurement for the first, multicentre sampling for the second, and prospective extraction or statistical adjustment of digital setup variables for the third.

Table 7
Outcome-specific certainty of evidence.

Outcome	Directness of evidence	Main limitations	Certainty	Interpretation
Post-treatment POB prevalence/frequency	One small direct retrospective comparative study; adjacent occlusal-contact and OGS studies are contextual.	Binary two-dimensional surrogate; small sample; POB already present at baseline; individual transitions/new cases not reported; indirect studies use different outcomes.	Low	38.6% is a post-treatment prevalence estimate in one adult CAT cohort. Treatment-emergent incidence is unknown; adjacent contact studies support the construct, not the numerical prevalence.
Millimetric POB magnitude	Two direct cohorts measured posterior cusp separation in millimetres.	Different definitions, populations, timepoints and units of analysis; neither used the prespecified single most affected tooth-pair endpoint.	Very low	Direct magnitude data provide empirical anchors for the proposed classification; outcome-linked prognostic cut-points remain to be quantified.
Mechanism	Direct tooth-position data plus indirect clinical and biomechanical evidence.	No study concurrently measures competing mechanisms or isolates passive bite-block causation.	Low to very low	Small posterior intrusive changes occur, but mechanism dominance and mechanism-specific gap thresholds cannot be established.
Spontaneous resolution	No direct post-aligner longitudinal cohort using a standardized millimetric POB endpoint.	Extrapolation from adjacent retention/settling literature.	Very low	Grade-specific closure probabilities and time-to-resolution cannot currently be estimated.
Management	One prospective cohort of vertical settling elastics plus case-based and expert-informed management evidence.	Selected populations; non-randomized management; no comparative effectiveness trial; limited follow-up.	Very low	Management should be diagnosis-led; no strategy can be considered superior on current evidence.

Outcome	Directness of evidence	Main limitations	Certainty	Interpretation
Brand-specific differences	No head-to-head clinical studies with a standardized POB endpoint.	Material-property evidence is indirect and cannot be translated into clinical risk.	Very low	No brand-specific POB risk estimate is possible.

Discussion

This review brings together the available evidence on a clinical entity that is widely recognized at the chairside but inadequately characterized in the peer-reviewed literature. Four points warrant emphasis.

First, visible posterior disocclusion can be present at debond, but its population prevalence and treatment-emergent incidence after clear aligner therapy remain uncertain. The best direct binary estimate is a post-treatment prevalence from one small retrospective cephalometric cohort; because baseline POB was already present and individual transitions were not reported, incidence of new POB cannot be derived. The same study also observed post-treatment POB after fixed appliances, so the finding is not specific to aligners.

Second, the relationship between POB magnitude and mechanism remains unresolved. Small posterior intrusive changes have been measured during CAT, but passive bite-block causation has not been isolated. Anterior interference, posterior tooth-position changes, transverse cusp disocclusion and inhibited settling remain plausible and potentially coexisting mechanisms. The classification therefore uses magnitude as the stable descriptive axis and mechanism as a parallel diagnostic axis: grade organizes the finding, but does not replace diagnosis.

Third, the available evidence does not support a comparative statement about POB risk between commercial aligner brands. Material differences are biologically plausible but cannot currently be translated into clinical risk estimates.

Fourth, the central evidence gap is longitudinal and quantitative. A prospective multicentre cohort should measure posterior inter-arch separation in millimetres at debond and through retention while concurrently recording anterior contacts, posterior tooth position, transverse relationships, treatment-plan variables and patient-reported function. The proposed classification provides ready-made strata for this work, allowing investigators to test whether increasing grade is associated with persistence, functional consequences or need for active correction.

Comparison with previous reviews

Existing reviews have addressed anterior open-bite correction[54, 55]and vertical control during distalization[56], documenting posterior vertical changes of generally modest magnitude. They do not

establish the incidence, natural history or mechanism of iatrogenic post-aligner POB. To our knowledge, the present review is the first systematic synthesis focused specifically on this clinical finding and the first to translate the available millimetric and mechanistic evidence into a four-tier, mechanism-aware clinical classification.

Limitations

The review has limitations beyond those of the underlying studies. Grey literature and clinical management sources were used only for contextual practice information and cannot provide incidence estimates. The proposed thresholds are consensus-defined, evidence-informed magnitude bands rather than outcome-derived prognostic cut-points; the direct 2026 cusp-distance cohorts provide numerical anchors, but do not determine where persistence, functional impact or treatment need changes. Posterior molar intrusion studies support the existence of small vertical changes but do not isolate passive bite-block causation or measure the residual POB gap. Adjacent OGS and digital-contact studies support the construct of posterior contact deficiency but cannot corroborate a numerical POB prevalence. Single case reports were excluded from the primary synthesis, potentially reducing representation of atypical mechanisms. Eligibility required an English full text or a language for which reliable translation was available, which may introduce language-availability bias. Finally, the evidence is dominated by Invisalign® cohorts and should not be generalized to other aligner systems as a brand-specific risk estimate.

These limitations do not invalidate the synthesis, but they define how the evidence should be used. Cephalometric studies should support the existence of a vertical or occlusal-contact phenomenon, whereas intraoral-scan or digital contact studies should be prioritized for future severity grading. Single-provider studies should be interpreted as internally consistent proof-of-concept evidence rather than population-level estimates. Studies with heterogeneous digital treatment plans should not be pooled unless planned movement, auxiliaries and refinement protocols are sufficiently reported to permit stratification or statistical adjustment.

Implications for clinical practice

Three clinical implications follow. First, posterior disocclusion should be documented as a measurable post-treatment occlusal finding rather than dismissed as a generic 'settling' problem. Second, the proposed grade should be recorded together with side, the most affected tooth pair, measurement method and suspected mechanism; this creates a reproducible language for referral, audit and research. Third, retention and corrective mechanics should remain mechanism-led so that attempts to improve posterior contacts do not compromise the stability of corrected tooth positions.

Implications for future research

Four priority studies follow from this synthesis. The highest priority is a prospective multicentre cohort applying the proposed classification at debond and at 1, 3, 6 and 12 months, with standardized intraoral-

scan registration, occlusal-contact analysis and concurrent assessment of anterior interference and transverse relationships. A second priority is a nested study comparing persistent versus resolved POB across classification grades on masticatory function, bite force and DC/TMD status. A third priority is a pragmatic comparative study of diagnosis-led management strategies, such as supervised settling protocols, vertical elastics and targeted refinement, stratified by baseline grade and mechanism. A fourth priority is a matched multicentre cohort comparing aligner systems with adjustment for operator, malocclusion, treatment plan and case complexity.

A prospective test of the classification should use intraoral scans as the primary endpoint, with the posterior gap measured separately on the right and left sides at the most affected premolar or molar pair in maximum intercuspation. The measurement protocol should specify mandibular position, tooth pair, surface-to-surface distance threshold, and intra- and inter-examiner reliability. Lateral cephalograms may remain useful for molar vertical change and mandibular rotation, but should be prespecified as secondary mechanistic outcomes rather than as the primary diagnostic method for POB.

The same study should include multiple providers and centres, record operator experience, and prospectively collect a minimum digital-treatment-plan dataset: planned molar intrusion or extrusion, planned incisor intrusion or retraction, anteroposterior correction, expansion amount, attachment strategy, elastics, IPR, number of refinement scans, aligner material or brand, wear compliance and retention design. Multivariable or mixed-effects models should separate appliance effects from operator and treatment-plan effects. This design would directly address the three main criticisms of the current evidence base and quantify the prognostic performance of the classification against persistence, masticatory function and need for active intervention.

Conclusions

Posterior open bite or posterior disocclusion is a clinically relevant post-treatment finding after clear aligner therapy, but the evidence base remains sparse and heterogeneous. One small retrospective comparative study reported visible POB at debond in 38.6% of adult aligner patients; because baseline POB was present and individual transitions were unavailable, this is a post-treatment prevalence estimate rather than treatment-emergent incidence. Two recent cohorts provide direct millimetric cusp-separation data, while adjacent occlusal-contact and posterior vertical-change studies support a multi-mechanism model. On this evidence, we propose a four-tier mechanism-aware clinical classification: sub-clinical (< 0.5 mm), mild (0.5–1.5 mm), moderate (> 1.5–3.0 mm) and severe (> 3.0 mm). The classification separates magnitude from mechanism, provides a common language for clinical documentation and research, and establishes a structured platform for prospective study of persistence, functional relevance and treatment response.

Abbreviations

AOB

anterior open bite
CAT
clear aligner therapy
CBCT
cone-beam computed tomography
DC/TMD
Diagnostic Criteria for Temporomandibular Disorders
JBI
Joanna Briggs Institute
PETG
polyethylene terephthalate glycol
POB
posterior open bite
PRISMA
Preferred Reporting Items for Systematic Reviews and Meta-Analyses
ROBINS-I
Risk Of Bias In Non-randomized Studies of Interventions
SIS
Sydney Intrusion Spring
TAD
temporary anchorage device
TMD
temporomandibular disorder.

Declarations

Acknowledgements

The authors thank the Italian Society of Orthodontics for the supportive forum in which the early ideas behind this review were discussed.

Availability of data and materials

No participant-level dataset was generated for this review. Data extracted for the synthesis are reported in the manuscript and Supplementary Materials; the protocol and protocol/deviation documentation are available through the OSF record ([10.17605/OSF.IO/WG4AZ](https://doi.org/10.17605/OSF.IO/WG4AZ)).

Consent for publication

Not applicable.

Trademark acknowledgements

Invisalign®, SmartTrack®, and ClinCheck® are registered trademarks of Align Technology Inc., San Jose, California, USA. ClearCorrect® and ClearQuartz™ are trademarks of Straumann Group, Basel, Switzerland (Zendura® is a registered trademark of Bay Materials LLC, Fremont, California, USA, licensed to Straumann). Spark® and TruGEN™ are trademarks ofOrmco Corporation, Brea, California, USA. 3M™ and Clarity™ are trademarks of Solventum, Maplewood, Minnesota, USA. F22 Aligner is a trademark of Sweden & Martina, Due Carrare, Italy. MasterControl S™ is a trademark of Angelalign Technology, Shanghai, China. Tera Harz TC-85 is a registered trademark of Graphy Inc., Seoul, Republic of Korea. T-Scan® is a registered trademark of Tekscan Inc., Norwood, Massachusetts, USA. All other trademarks remain the property of their respective owners.

References

1. Papadimitriou A, Mousouleas S, Gkantidis N, Kloukos D. Clinical effectiveness of Invisalign orthodontic treatment: a systematic review. *Prog Orthod*. 2018;19:37.
2. Robertson L, Kaur H, Fagundes NCF, Romanyk D, Major P, Flores-Mir C. Effectiveness of clear aligner therapy for orthodontic treatment: a systematic review. *Orthod Craniofac Res*. 2020;23:133–42.
3. Abela S. *Aligner Systems in Invisible Orthodontics: Basic Concepts and Clinical Management*. Cham: Springer; 2024.
4. Kravitz ND, Kusnoto B, BeGole E, Obrez A, Agran B. How well does Invisalign work? A prospective clinical study evaluating the efficacy of tooth movement with Invisalign. *Am J Orthod Dentofac Orthop*. 2009;135:27–35.
5. Haouili N, Kravitz ND, Vaid NR, Ferguson DJ, Makki L. Has Invisalign improved? A prospective follow-up study on the efficacy of tooth movement with Invisalign. *Am J Orthod Dentofac Orthop*. 2020;158:420–5.
6. Castroflorio T, Parrini S, Rossini G. Aligner biomechanics: where we are now and where we are heading for. *J World Fed Orthod*. 2024;13:57–64.
7. D'Antò V, Oliva G, Nieri M, Clauser T, Statie MD, Nucci L, et al. Indications and limits of clear aligner therapy: an international modified Delphi consensus study. *Prog Orthod*. 2025;26:28.
8. Sabouni W, Venugopal A, Adel SM, Vaid N. Correction of anterior open bite of varying severity using clear aligner therapy: a case series. *Clin Case Rep*. 2022;10:e6277.
9. Arveda N, Calza M, Castroflorio T, Garino F, Giancotti A, Varela JC, et al. Clear aligner orthodontic treatment: an international modified Delphi consensus study. *Am J Orthod Dentofac Orthop*. 2025;168:620–38.
10. Harris K, Ojima K, Dan C, Upadhyay M, Alshehri A, Kuo CL, et al. Evaluation of open bite closure using clear aligners: a retrospective study. *Prog Orthod*. 2020;21:23. 10.1186/s40510-020-00325-5.
11. Alyami B. Diagnosis and management of a unilateral posterior open bite using a temporary anchorage device (TAD): case report and review of the literature. *Case Rep Dent*.

2020;2020:9814949.

12. Gudhimella S, Gandhi V, Leigh Schiro N, Janakiraman N. Management of anterior open bite and skeletal Class II hyperdivergent patient with clear aligner therapy. *Turk J Orthod.* 2022;35:139–49.
13. Bichu YM, Alwafi A, Liu X, Andrews J, Ludwig B, Bichu AY, et al. Advances in orthodontic clear aligner materials. *Bioact Mater.* 2023;22:384–403.
14. Lombardo L, Martines E, Mazzanti V, Arreghini A, Mollica F, Siciliani G. Stress relaxation properties of four orthodontic aligner materials: a 24-hour in vitro study. *Angle Orthod.* 2017;87:11–8.
15. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ.* 2021;372:n71.
16. Xiao L, Wen S, Yuan X, He X, Han X, Guan X, et al. Vertical settling elastics for resolving posterior open bite during the fine-tuning staging for clear aligner therapy: a prospective clinical study. *Am J Orthod Dentofac Orthop.* 2026;170:65–76. 10.1016/j.ajodo.2026.01.028.
17. Zhuo Y, Guo F, Huang S, Lei L. The 'roller coaster effect' in clear aligner premolar extraction cases: posterior open bite and cephalometric risk factors. *Orthod Craniofac Res.* 2026. 10.1111/ocr.70136.
18. Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ.* 2016;355:i4919.
19. Munn Z, Barker TH, Moola S, Tufanaru C, Stern C, McArthur A, et al. Methodological quality of case series studies: an introduction to the JBI critical appraisal tool. *JBI Evid Synth.* 2020;18:2127–33.
20. Shea BJ, Reeves BC, Wells G, Thuku M, Hamel C, Moran J, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ.* 2017;358:j4008. 10.1136/bmj.j4008.
21. Akinwale-Quansah A, Singh P. Clear aligner treatment and the generation of posterior open bites: aetiology, treatment and prevention. *J Orthod.* 2026;53:158–69. 10.1177/14653125261426388.
22. Rask H, English JD, Colville C, Kasper FK, Gallerano R, Jacob HB. Cephalometric evaluation of changes in vertical dimension and molar position in adult non-extraction treatment with clear aligners and traditional fixed appliances. *Dent Press J Orthod.* 2021;26:e2119360.
23. Talens-Cogollos L, Vela-Hernández A, Peiró-Guijarro MA, García-Sanz V, Montiel-Company JM, Gandía-Franco JL, et al. Unplanned molar intrusion after Invisalign treatment. *Am J Orthod Dentofac Orthop.* 2022;162:451–8.
24. Moshiri S, Araújo EA, McCray JF, Thiesen G, Kim KB. Cephalometric evaluation of adult anterior open bite non-extraction treatment with Invisalign. *Dent Press J Orthod.* 2017;22:30–8.
25. Garnett BS, Mahood K, Nguyen M, Al-Khateeb A, Liu S, Boyd R, et al. Cephalometric comparison of adult anterior open bite treatment using clear aligners and fixed appliances. *Angle Orthod.* 2019;89:3–9.
26. Khosravi R, Cohananim B, Hujoel P, Daher S, Neal M, Liu W et al. Management of overbite with the Invisalign appliance. *Am J Orthod Dentofacial Orthop.* 2017;151:691-9.e2.

27. Lo-Cao D, Pandis N, Darendeliler MA, Papadopoulou AK. A 3-dimensional comparative assessment of the dentoskeletal effects of clear aligners versus temporary skeletal anchorage device-assisted posterior intrusion in adolescents with anterior open bite: a single-center, retrospective, cohort study. *Am J Orthod Dentofac Orthop.* 2025;167:345–61. 10.1016/j.ajodo.2024.10.017.
28. Suh H, Garnett BS, Mahood K, Mahjoub N, Boyd RL, Oh H. Treatment of anterior open bites using non-extraction clear aligner therapy in adult patients. *Korean J Orthod.* 2022;52:210–9.
29. Pinho T, Marcelino V, Gonçalves M, Azevedo RMS, Rocha D, Paço M. The impact of clear aligner treatment in masticatory function and temporomandibular disorders: a clinical cohort pilot study. *Healthc (Basel).* 2025;13:1541.
30. Djeu G, Shelton C, Maganzini A. Outcome assessment of Invisalign and traditional orthodontic treatment compared with the American Board of Orthodontics objective grading system. *Am J Orthod Dentofac Orthop.* 2005;128:292–8. 10.1016/j.ajodo.2005.06.002.
31. Buschang PH, Ross M, Shaw SG, Crosby D, Campbell PM. Predicted and actual end-of-treatment occlusion produced with aligner therapy. *Angle Orthod.* 2015;85:723–7. 10.2319/043014-311.1.
32. Bowman E, Bowman P, Weir T, Dreyer C, Meade MJ. Occlusal contacts and treatment with the Invisalign appliance: a retrospective analysis of predicted vs achieved outcomes. *Angle Orthod.* 2023;93:275–81. 10.2319/102822-738.1.
33. Frenkel ES, Mustafa M, Khosravi R, Woloshyn H, Mancl L, Bollen AM. Occlusal contact changes in patients treated with clear aligners: a retrospective evaluation using digital dental models. *Am J Orthod Dentofac Orthop.* 2024;165:680–e84. 10.1016/j.ajodo.2024.01.015.
34. Marcelino V, Baptista S, Marcelino S, Paço M, Rocha D, Gonçalves MDP, et al. Occlusal changes with clear aligners and the case complexity influence: a longitudinal cohort clinical study. *J Clin Med.* 2023;12:3435. 10.3390/jcm12103435.
35. Oliva G, Maddaluno R, Rongo R, Buonocore G, Valletta R, Michelotti A, D'Antò V. Difference in occlusal contacts obtained with conventional orthodontic and clear aligner therapy: a pilot study. *Dent J (Basel).* 2026;14:169. 10.3390/dj14030169.
36. Patterson BD, Foley PF, Ueno H, Mason SA, Schneider PP, Kim KB. Class II malocclusion correction with Invisalign: Is it possible? *Am J Orthod Dentofac Orthop.* 2021;159:e41–8. 10.1016/j.ajodo.2020.08.016.
37. Ke Y, Zhu Y, Zhu M. A comparison of treatment effectiveness between clear aligner and fixed appliance therapies. *BMC Oral Health.* 2019;19:24. 10.1186/s12903-018-0695-z.
38. Papageorgiou SN, Koletsi D, Iliadi A, Peltomaki T, Eliades T. Treatment outcome with orthodontic aligners and fixed appliances: a systematic review with meta-analyses. *Eur J Orthod.* 2020;42:331–43. 10.1093/ejo/cjz094.
39. Castroflorio T, Sedran A, Parrini S, Garino F, Reverdito M, Capuozzo R, et al. Predictability of orthodontic tooth movement with aligners: effect of treatment design. *Prog Orthod.* 2023;24:2.
40. Houle JP, Piedade L, Todescan R Jr, Pinheiro FH. The predictability of transverse changes with Invisalign. *Angle Orthod.* 2017;87:19–24.

41. Lione R, Paoloni V, Bartolommei L, Gazzani F, Meuli S, Pavoni C, et al. Maxillary arch development with Invisalign system: analysis of expansion dental movements on digital dental casts. *Angle Orthod.* 2021;91:433–40.
42. Zhang Y, Hui S, Gui L, Jin F. Effects of upper arch expansion using clear aligners on different stride and torque: a three-dimensional finite element analysis. *BMC Oral Health.* 2023;23:891.
43. Sauget E, Covell DA Jr, Boero RP, Lieber WS. Comparison of occlusal contacts with use of Hawley and clear overlay retainers. *Angle Orthod.* 1997;67:223–30.
44. Bauer EM, Behrents R, Oliver DR, Buschang PH. Posterior occlusion changes with a Hawley vs Perfector and Hawley retainer: a follow-up study. *Angle Orthod.* 2010;80:853–60.
45. Sari Z, Uysal T, Başçiftci FA, Inan O. Occlusal contact changes with removable and bonded retainers in a 1-year retention period. *Angle Orthod.* 2009;79:867–72.
46. Dincer M, Isik Aslan B. Effects of thermoplastic retainers on occlusal contacts. *Eur J Orthod.* 2010;32:6–10.
47. Palone M, Longo M, Arveda N, Nacucchi M, De Pascalis F, Spedicato GA, et al. Micro-computed tomography evaluation of general trends in aligner thickness and gap width after thermoforming procedures involving six commercial clear aligners: an in vitro study. *Korean J Orthod.* 2021;51:135–41.
48. Bucci R, Rongo R, Levatè C, Michelotti A, Barone S, Razionale AV, et al. Thickness of orthodontic clear aligners after thermoforming and after 10 days of intraoral exposure: a prospective clinical study. *Prog Orthod.* 2019;20:36.
49. Kravitz ND, Dalloul B, Zaid YA, Shah C, Vaid NR. What percentage of patients switch from Invisalign to braces? A retrospective study evaluating the conversion rate, number of refinement scans, and length of treatment. *Am J Orthod Dentofac Orthop.* 2023;163:526–30.
50. Marzouk ES, Kassem HE. Evaluation of long-term stability of skeletal anterior open bite correction in adults treated with maxillary posterior segment intrusion using zygomatic miniplates. *Am J Orthod Dentofac Orthop.* 2016;150:78–88.
51. Almalki SA, Al Jameel ABH, Gowdar IM, Langaliya A, Vaddamanu SK, Di Blasio M, et al. Impact of clear aligner therapy on masticatory musculature and stomatognathic system: a systematic review conducted according to PRISMA guidelines and the Cochrane handbook for systematic reviews of interventions. *BMC Oral Health.* 2024;24:350.
52. Sicilia L, Miranda GHN, Fattori L, Furquim BD, Normando D. Impact of clear aligners on the temporomandibular joint: a systematic review. *Orthod Craniofac Res.* 2025;29:209–24.
53. Lee SH, Fang ML, Choi YJ, Yu HS, Kim JH, Hu KS, et al. Changes in masticatory performance during the retention period following 4-premolar extraction and non-extraction orthodontic treatment. *Clin Oral Investig.* 2023;27:2609–19.
54. Olteanu ND, Romanec C, Cernei ER, Karvelas N, Nastri L, Zetu IN. Scoping review: the effectiveness of clear aligners in the management of anterior open bite in adult patients. *Med (Kaunas).* 2025;61:1113.

55. Blundell HL, Weir T, Byrne G. Predictability of anterior open bite treatment with Invisalign. Am J Orthod Dentofac Orthop. 2023;164:674–81.

56. Park TH, Shen C, Chung CH, Li C. Vertical control in molar distalization by clear aligners: a systematic review and meta-analysis. J Clin Med. 2024;13:2845.

Figures

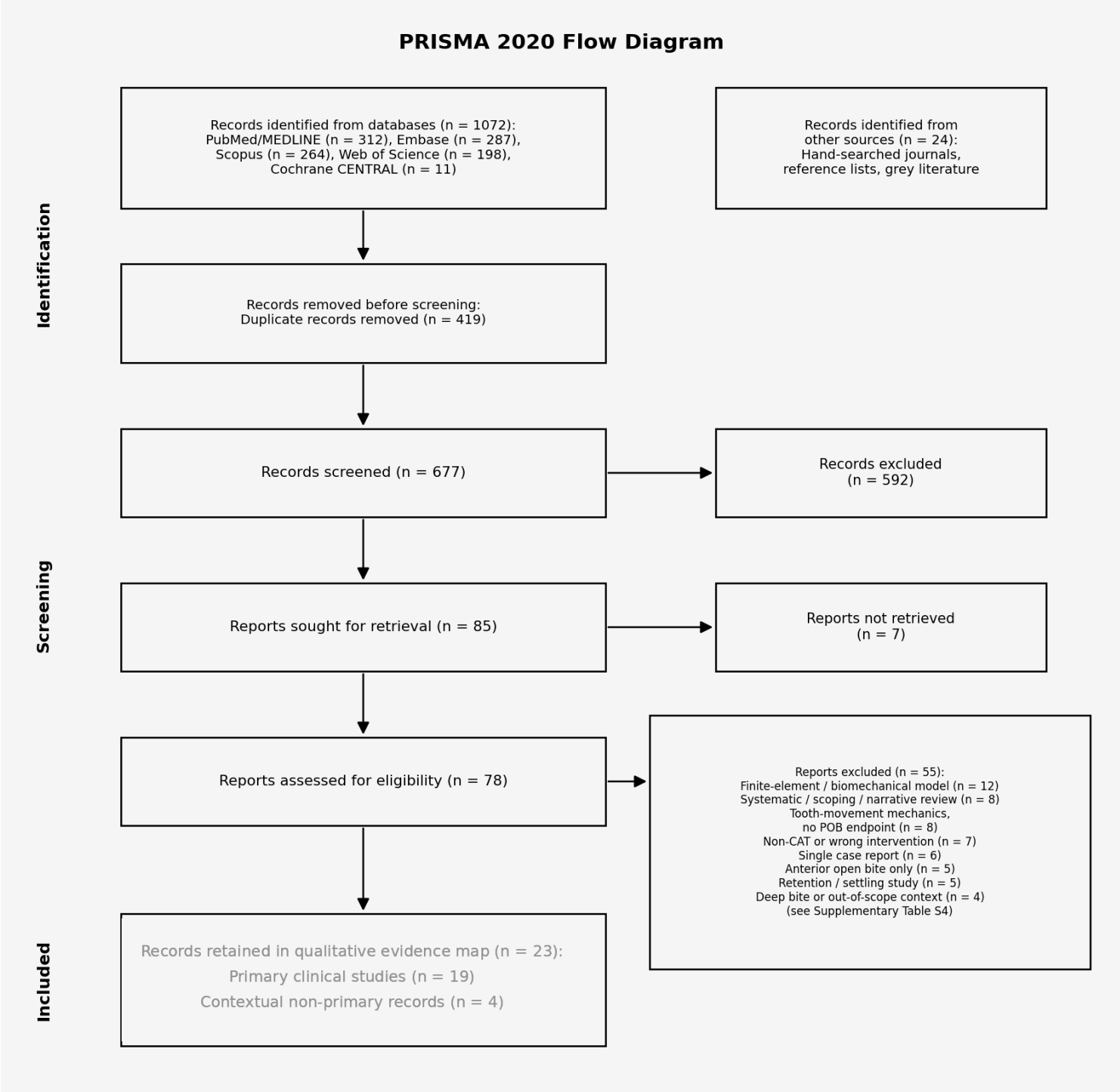


Figure 1

PRISMA 2020 flow diagram of study identification, screening, eligibility and inclusion. This was executed till May 2026 and adapted from Page MJ et al. BMJ 2021;372:n71.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryMaterialS1.docx](#)