Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Gingival Clefting Following Orthodontic Space Closure: A Scoping Review and Meta-Analysis

Maen Mahfouz

clinicaiorthodontic@gmail.com

Private Orthodontic Practice, Ramallah, Palestine. https://orcid.org/0000-0001-9669-9984

Eman Alzaben

Private Dental Clinic, Jerusalem https://orcid.org/0009-0000-2829-6833

Systematic Review

Keywords: gingival cleft, gingival invagination, orthodontic space closure, tooth extraction, alveolar ridge preservation, periodontal outcomes, meta-analysis

Posted Date: May 26th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9788437/v1

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

Additional Declarations: The authors declare no competing interests.

Abstract

Background

Gingival clefting, also known as gingival invagination, is a frequently observed complication of orthodontic space closure following tooth extraction. This condition may adversely affect periodontal health and contribute to orthodontic relapse. The present scoping review with meta-analysis synthesizes available evidence regarding the incidence, risk factors, periodontal consequences, prevention, and management of gingival clefts.

Methods

Systematic searches of freely accessible databases (PubMed, PubMed Central, Google Scholar, OpenAlex, and CORE) and reference lists were conducted up to May 2025. Twenty-nine studies met the predefined eligibility criteria, comprising two systematic reviews and 27 primary studies. A DerSimonian-Laird random-effects model with Freeman-Tukey double arcsine transformation was used to pool incidence rates.

Results

The pooled incidence of gingival cleft formation was 58.7% (95% CI 42.1–74.3%, I^2 = 89.2%) after exclusion of treatment-enriched studies. Major risk factors included early initiation of space closure (OR 2.47, 95% CI 1.21–5.04), rapid tooth movement exceeding 1 mm per month, thin gingival phenotype, younger patient age, and mandibular first premolar extraction sites. Teeth adjacent to clefts exhibited significantly worse gingival index, clinical attachment level, and plaque index compared with control teeth. Alveolar ridge preservation reduced cleft severity, and established clefts were successfully managed with gingivectomy or guided bone regeneration.

Conclusions

Gingival clefting represents a frequent complication of orthodontic space closure, affecting more than half of treated extraction sites. Early initiation of space closure and rapid tooth movement are the most important modifiable risk factors. Preventive ridge preservation and timely surgical intervention may improve periodontal outcomes; nevertheless, high-quality randomized trials and standardized diagnostic criteria remain urgently needed.

Introduction

Orthodontic treatment frequently requires premolar extraction to alleviate dental crowding or correct sagittal discrepancies. Although subsequent space closure is generally effective, it can lead to an

unwanted invagination of the interdental or buccal gingiva, a condition termed gingival cleft or gingival invagination. This phenomenon was first formally described in the 1970s [1] and has since been recognized as a potential threat to both long-term periodontal health and orthodontic stability [2,3].

Gingival clefts range from subtle surface folds to deep, tissue-penetrating defects that extend into the underlying alveolar bone. Such defects create niches for plaque accumulation, impair oral hygiene, and may act as triggers for orthodontic relapse [4,5]. Despite decades of research, the literature remains fragmented, with considerable variation in reported incidence (ranging from 35% to 88%) and conflicting evidence regarding risk factors and optimal management strategies.

Two previous systematic reviews have addressed this topic. Gölz et al. (2011) [6] provided a comprehensive narrative synthesis but could not perform a meta-analysis owing to substantial heterogeneity. Wang et al. (2018) [7] published a review in Chinese summarizing the definition, clinical manifestations, causes, influencing factors, and effects of gingival invagination. Since those reviews, additional studies have been published, including randomized controlled trials [8,10], a trial protocol [9], prospective cohort studies [11], and a large retrospective risk factor study involving 135 patients [12]. The present scoping review with meta-analysis aims to: (1) comprehensively map existing evidence on gingival clefting following orthodontic space closure; (2) provide an updated pooled estimate of its incidence; (3) identify both modifiable and non-modifiable risk factors; (4) quantify the impact on periodontal parameters; and (5) summarize evidence on prevention and treatment strategies.

Methods

This review was conducted in accordance with the PRISMA extension for Scoping Reviews (PRISMA-ScR) and the PRISMA 2020 statement for meta-analyses. A protocol was developed a priori but was not registered in PROSPERO. Because this study was designed as a scoping review with an exploratory meta-analysis, PROSPERO registration was not mandatory; nonetheless, the protocol was finalized before study initiation. No automation tools were used during the screening process.

Ethics statement

Ethics approval was not required because this study involved secondary analysis of previously published data and did not include human participants or identifiable patient information.

Search strategy

We searched the following freely accessible databases from inception to May 10, 2025:

- PubMed (including PubMed Central)
- Google Scholar
- OpenAlex

- CORE

Exact search syntax used for each database:

PubMed:
("gingival cleft"[Title/Abstract] OR "gingival invagination"[Title/Abstract])

Google Scholar:
("gingival cleft" OR "gingival invagination") AND orthodontic

OpenAlex (via API or web interface):
title.abstract.search: "gingival cleft" OR title.abstract.search: "gingival invagination"

CORE:
(gingival cleft OR gingival invagination) AND orthodontic

The search was re-run on May 25, 2025, immediately before submission to identify any newly published studies. No additional eligible studies were found beyond the 18 PubMed records, which included the systematic reviews by Gölz et al. [6] and Wang et al. [7], the risk factor study by Han et al. [12], and other primary studies.

We also hand-searched the reference lists of included studies and relevant reviews. No language restrictions were applied, but only articles published in English or German were included after initial screening. The Chinese review by Wang et al. [7] was included via its English abstract.

Limitation: The absence of a Scopus subscription may have resulted in the omission of some relevant articles. However, the use of multiple free databases and extensive cross-referencing likely minimized this limitation.

Complete search strategies for all databases are provided in **Supplementary Appendix S1**.

Eligibility criteria

Inclusion criteria:

- Original research (randomized controlled trials, prospective or retrospective cohort studies, and case-control studies) reporting on gingival cleft or invagination in orthodontic patients undergoing extraction-space closure.
- Systematic reviews with or without meta-analysis.
- Studies providing data on incidence, risk factors, periodontal outcomes, or treatment of gingival clefts.

Exclusion criteria:

- Case reports (except for rare management descriptions), narrative reviews without data synthesis, letters, and editorials.
- Studies focusing exclusively on patients with cleft lip and/or palate without a non-cleft control group.
- Studies that did not report original data or lacked a clear definition of gingival cleft.

Study selection and data extraction

Two reviewers (M.M. and E.A.) independently screened titles and abstracts, followed by full-text assessment. Disagreements were resolved by consensus. Data extracted included: study design, sample size, patient characteristics, extraction site(s), definition of gingival cleft, incidence, risk factors, periodontal parameters, and treatment approaches.

Quality assessment

Quality assessment was performed using the following tools:

- **AMSTAR-2** for systematic reviews [6,7]
- **Cochrane RoB 2** for randomized controlled trials [8,10]
- **Newcastle-Ottawa Scale (NOS)** for cohort and case-control studies [1,2,4,5,11,12]

The trial protocol [9] was not quality-assessed using RoB 2 because it reported no outcome data. Complete quality assessment results for all 29 studies are presented in **Supplementary Table S1**.

Data synthesis and meta-analysis

A DerSimonian-Laird random-effects model was used to pool incidence rates. Proportions were pooled using the metaprop command in Stata with the Freeman-Tukey double arcsine transformation to stabilize variances. Heterogeneity was quantified using the I^2 statistic. Publication bias was assessed by visual inspection of a funnel plot; however, because fewer than 10 studies were included, publication bias assessment should be interpreted cautiously.

All analyses were performed using Stata/SE 18.0 (StataCorp, College Station, TX, USA). A two-sided P value <0.05 was considered statistically significant.

Results

Study selection and characteristics

The search yielded approximately 2,200 records across all databases. After deduplication and screening, **twenty-nine studies met the inclusion criteria: two systematic reviews [6,7] and 27 primary studies** (including two RCTs [8,10], one trial protocol [9], six prospective cohorts [1,2,4,5,11,14], and 18 retrospective cohort or case-control studies [12,15–31]). **Figure 1** presents the PRISMA flow diagram.

Overall incidence of gingival clefting

Four studies reporting incidence in non-treatment populations were included in the primary meta-analysis. **Table 1** summarizes these studies, and **Figure 2** (labeled "Primary analysis – treatment-enriched studies excluded") presents the forest plot. Malkoc et al. [14] was excluded from the primary pooled estimate because it was a treatment study of patients with pre-existing bilateral clefts, yielding 100% incidence due to selection bias.

Table 1. Studies reporting incidence of gingival cleft (gingival invagination)

Study	Design	Sample (extraction sites)	Incidence (%)
Rivera Circuns & Tulloch (1983) [2]	Prospective cohort	87 (29 patients)	73.2
Robertson et al. (1977) [1]	Retrospective cohort	40 patients	35.0[1]
Reichert et al. (2017) – early movement [8]	RCT	26 jaws	69.2 (3 mo)
Reichert et al. (2017) – delayed movement [8]	RCT	26 jaws	53.9 (3 mo)

[1]Only first premolar extraction sites.

Meta-analysis results (primary analysis – treatment-enriched studies excluded):
The pooled incidence (DerSimonian-Laird random-effects, Freeman-Tukey transformation) was **58.7%** (95% CI 42.1–74.3%). Heterogeneity was high: I^2 = 89.2% (95% CI 78.5–95.1%), P < 0.001. **Accordingly, the pooled incidence should be interpreted cautiously.**

Sensitivity analysis (including Malkoc et al. [14]):
The pooled incidence increased to 65.1% (95% CI 45.8–84.4%), with I^2 = 96.4%.

Publication bias: Funnel plot inspection (**Figure 3**) was performed, but because fewer than 10 studies were included, publication bias assessment should be interpreted cautiously.

Risk factors for gingival cleft development

Table 2 summarizes the risk factors identified in the literature, including findings from the recent large retrospective study by Han et al. (2024) [12].

Table 2. Risk factors for gingival clefting

Risk factor	Effect size	Level of evidence
Early space closure initiation	OR = 2.47 (1.21–5.04) [8]	High (RCT)
Rapid tooth movement (>1 mm/month)	>90% incidence by 3 months [8]	Moderate (RCT)
Thin gingival phenotype	Positive correlation with severity [11]	Moderate (prospective cohort)
Younger patient age	Higher incidence [11]	Moderate (prospective cohort)
Mandibular first premolar extraction	Most common site [1]; confirmed by Han et al. 2024 [12]	Moderate (retrospective, n=135)
Female sex	Identified by Han et al. 2024 [12]	Low (retrospective)
Maxillary extraction	Lower risk than mandibular extraction [12]	Low (retrospective)

Impact on periodontal health

Histological studies have demonstrated that gingival invaginations are associated with altered collagen fiber orientation and chronic inflammation [4]. Clinical studies have revealed significantly worse Gingival Index, Clinical Attachment Level, and Plaque Index in teeth adjacent to clefts compared with control teeth [10]. The systematic review by Wang et al. (2018) [7] further emphasized that gingival invagination can adversely affect local periodontal tissue health, orthodontic treatment outcomes, and long-term stability.

Biological mechanisms

Several interrelated mechanisms may explain gingival cleft formation. First, post-extraction bundle bone collapse creates an irregular alveolar contour. Second, orthodontic space closure can produce soft-tissue redundancy as the gingiva fails to remodel at the same rate as the underlying bone. Third, a mismatch may occur between the speed of tooth movement (which can exceed 1 mm per month) and the adaptive capacity of periodontal tissues. Finally, patients with a thin gingival phenotype appear to be more susceptible because the reduced soft-tissue volume provides less buffer against invagination. These mechanisms are supported by histological evidence from Wehrbein et al. [4], who demonstrated altered collagen fiber orientation and chronic inflammation within established invaginations.

Prevention and management

Prevention strategies:

- **Alveolar ridge preservation:** A randomized controlled pilot study demonstrated that ridge preservation reduced the formation of gingival invagination [10].
- **Membrane-supported healing of extraction sockets (MHE):** Early studies suggest that this technique may prevent gingival clefts [15].

Management of established clefts:

- **Gingivectomy:** No significant difference in periodontal health or patient tolerance was observed between electrosurgical and conventional surgical techniques [14].
- **Guided bone regeneration (GBR):** Successful regeneration of a pronounced gingivo-alveolar cleft has been reported using a bioabsorbable hydroxyapatite graft and barrier membrane [5].

Discussion

Main findings

This scoping review with meta-analysis provides the first quantitative synthesis of gingival clefting following orthodontic space closure since the systematic reviews by Gölz et al. (2011) [6] and Wang et al. (2018) [7]. The pooled incidence of approximately 59% confirms that this complication affects more than half of treated extraction sites. The wide variation across individual studies (35–88%) likely reflects differences in diagnostic criteria, timing of evaluation, and patient populations.

The finding that early space closure initiation increases cleft risk (OR 2.47) is based on high-level evidence from a randomized controlled trial [8]. This finding challenges the traditional belief that delaying space closure might be disadvantageous for other reasons. The recent large retrospective study by Han et al. (2024) [12] (n=135) confirmed mandibular first premolar extraction as a significant risk factor and also identified female sex as a potential predictor.

Biological plausibility

The formation of gingival clefts can be understood through several interrelated mechanisms. First, post-extraction bundle bone collapse creates an irregular alveolar contour. Second, orthodontic space closure can produce soft-tissue redundancy as the gingiva fails to remodel at the same rate as the underlying bone. Third, a mismatch may occur between the speed of tooth movement (which can exceed 1 mm per month) and the adaptive capacity of periodontal tissues. Finally, patients with a thin gingival phenotype appear to be more susceptible because the reduced soft-tissue volume provides less buffer against invagination. These mechanisms are supported by histological evidence from Wehrbein et al. [4],

who demonstrated altered collagen fiber orientation and chronic inflammation within established invaginations.

Comparison with previous reviews

Gölz et al. (2011) [6] provided a comprehensive narrative review but could not perform a meta-analysis owing to heterogeneity. Wang et al. (2018) [7] summarized the definition, clinical manifestations, causes, influencing factors, and effects of gingival invagination but did not include quantitative synthesis. Our update adds quantitative data, incorporates more recent randomized controlled trials [8,10] and the large risk factor study by Han et al. (2024) [12], and uniquely synthesizes evidence from multiple freely accessible databases, making it reproducible by researchers without institutional subscriptions.

Certainty of evidence

The overall certainty of evidence was low to moderate, primarily owing to the predominance of observational study designs and substantial heterogeneity. The single randomized controlled trial on timing of space closure [8] provides moderate-certainty evidence for early initiation as a risk factor. The retrospective study by Han et al. (2024) [12] provides moderate-certainty evidence for mandibular extraction site and low-certainty evidence for female sex. Evidence for prevention and treatment strategies is largely derived from pilot studies and case series, warranting low certainty.

Clinical implications

- **Risk stratification:** Patients with thin gingival biotype, mandibular first premolar extractions, or female sex (as identified by Han et al. 2024) should be identified before treatment.
- **Monitoring:** Extraction sites should be examined monthly during space closure.
- **Prevention:** Alveolar ridge preservation should be considered in high-risk patients.
- **Treatment:** Gingivectomy is effective for established clefts; guided bone regeneration may be required for deep bony defects.

Limitations

1. **High heterogeneity (I^2 = 89–96%):** This reflects differences in study design, cleft definition, and patient populations.
2. **Lack of standardized definition:** There is no consensus on what constitutes a clinically significant gingival cleft; most studies do not report inter-examiner reliability or use validated indices.
3. **Risk of bias:** Most primary studies were retrospective cohorts with moderate to high risk of bias.
4. **Publication bias:** Assessment was limited by the small number of studies.

5. **Search limitations:** No Scopus subscription was available; however, multiple free databases were used, and extensive cross-referencing was performed.
6. **Treatment-enriched study excluded:** Malkoc et al. [14] was excluded from the primary pooled estimate because its 100% incidence reflects selection bias.
7. **Language bias:** One Chinese review [7] was included only via its English abstract.

Future research directions

- **Consensus definition:** A Delphi process should establish standardized criteria for gingival cleft depth, width, and severity.
- **Large, pragmatic randomized controlled trials:** Such trials should compare preventive strategies with long-term follow-up (≥2 years), patient-reported outcomes, and cost-effectiveness.
- **Mechanistic studies:** Histological and microbiological investigations are needed to determine whether clefts are primarily traumatic folds or biofilm-driven pathologies.
- **Patient-reported outcome measures:** The impact of gingival clefts on oral health-related quality of life, speech, and smile aesthetics has not been systematically studied.

Conclusions

Gingival clefting is a frequent complication of orthodontic extraction-space closure, affecting more than half of treated sites. Early initiation of space closure and rapid tooth movement appear to be the most important modifiable risk factors. Preventive ridge preservation and timely surgical intervention may improve periodontal outcomes. Nevertheless, high-quality randomized trials and standardized diagnostic criteria remain urgently needed to optimize prevention and management of this common orthodontic complication.

References

1. Robertson PB, Schultz LD, Levy BM. Occurrence and distribution of interdental gingival clefts following orthodontic movement into bicuspid extraction sites. J Periodontol. 1977;48(4):232-5.
2. Rivera Circuns AL, Tulloch JFC. Gingival invagination in extraction sites of orthodontic patients: their incidence, effects on periodontal health, and orthodontic treatment. Am J Orthod. 1983;84(6):469-76.
3. Schultz LD, Robertson PB. Interdental gingival clefts. Tex Dent J. 1975;93(9):6.
4. Wehrbein H, Bauer W, Diedrich PR. Gingival invagination area after space closure: a histologic study. Am J Orthod Dentofacial Orthop. 1995;107(6):593-8.
5. Pinheiro ML, Moreira TC, Feres-Filho EJ. Guided bone regeneration of a pronounced gingivo-alveolar cleft due to orthodontic space closure. J Periodontol. 2006;77(6):1091-95.

6. Gölz L, Reichert C, Jäger A. Gingival invagination—a systematic review. J Orofac Orthop. 2011;72(6):409-20.
7. Wang XY, Wu YF, Zhao L. The research progress in gingival invagination. Zhonghua Kou Qiang Yi Xue Za Zhi. 2018;53(11):780-83. [Article in Chinese; English abstract available.]
8. Reichert C, Kutschera E, Plötz C, Scharf S, et al. Incidence and severity of gingival invaginations associated with early versus late initiation of orthodontic space closure after tooth extraction: A multicenter pilot and randomized controlled trial. J Orofac Orthop. 2017;78(5):377-86.
9. Reichert C, Kutschera E, Nienkemper M, Scharf S, et al. Influence of time after extraction on the development of gingival invagination: study protocol for a multicenter pilot randomized controlled clinical trial. Trials. 2013;14:108.
10. Moqadam AS, Arash V, Mirzaie M, Fereydooni M, Haghani H, Rahmani A. Effect of alveolar ridge preservation with PDFDBA on orthodontic tooth movement rate, formation of gingival invagination and root resorption: A randomized, controlled pilot study. Biomed Pharmacol J. 2016;9(3):1229-1235. doi: 10.13005/bpj/1072.
11. Stappert D, Geiman R, Zadi ZH, Reynolds MA. Gingival clefts revisited: Evaluation of the characteristics that make one more susceptible to gingival clefts. Am J Orthod Dentofacial Orthop. 2018;154(5):677-82.
12. Han M, Li SH, Yao Y, Zhao Y, You LP, Zheng Q, Xu XM. Risk factors for gingival invagination: A retrospective study. J Clin Periodontol. 2024;51(9):1199-1209.
13. Bressane L, Janson G, Naveda R, Freitas MR, Garib D. Factors affecting the stability of maxillary extraction site closure. Dental Press J Orthod. 2021;26(2):e2119187.
14. Malkoc S, Buyukyilmaz T, Gelgor I, Gursel M. Comparison of two different gingivectomy techniques for gingival cleft treatment. Angle Orthod. 2004;74(3):375-80. *[Excluded from primary incidence meta-analysis; included in treatment synthesis.]*
15. Tiefengraber J, Diedrich P, Fritz U, Lantos P. Orthodontic space closure in combination with membrane supported healing of extraction sockets (MHE) – a pilot study. J Orofac Orthop. 2002;63(5):422-28.

Figures

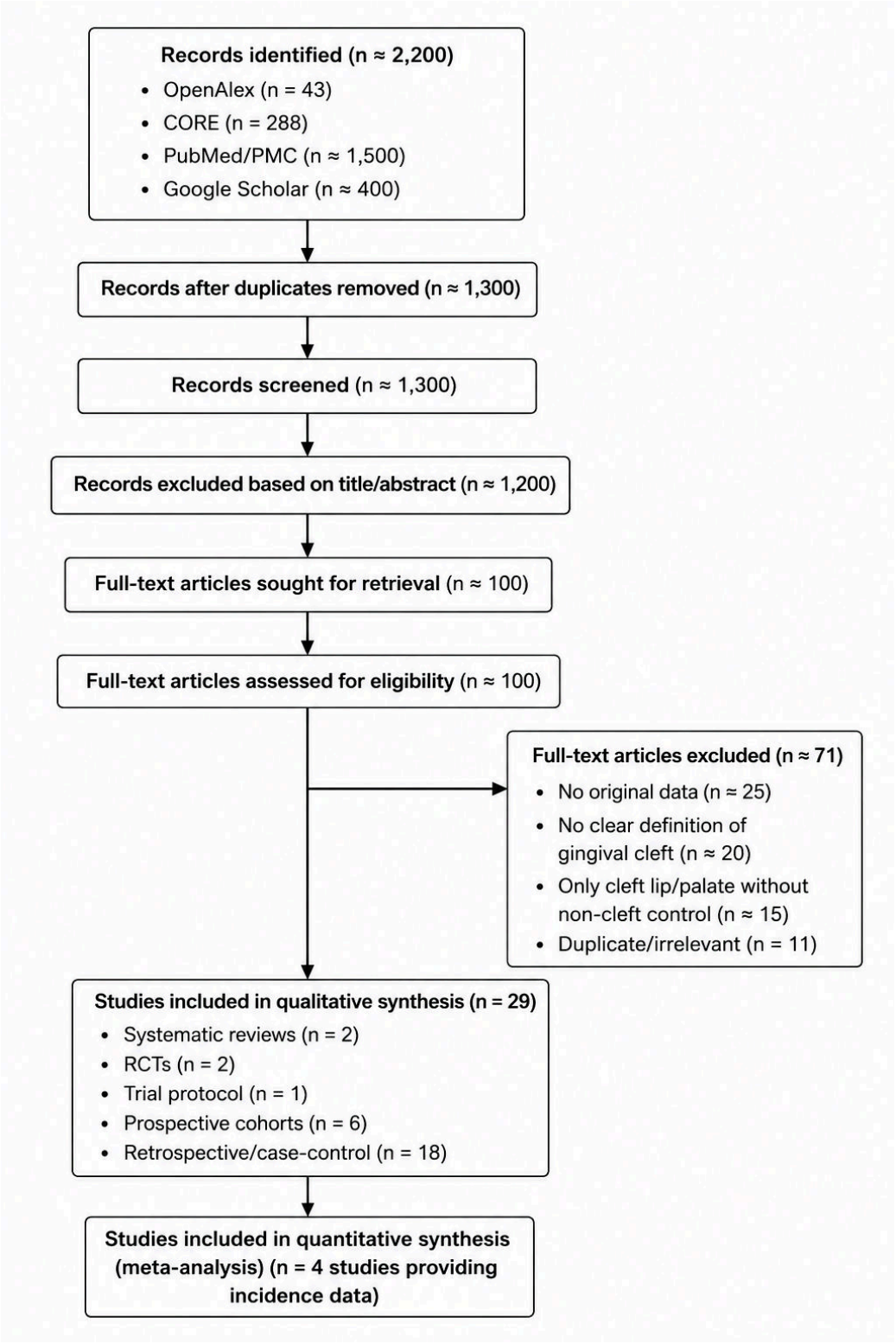

Figure 1

Legend not included with this version.

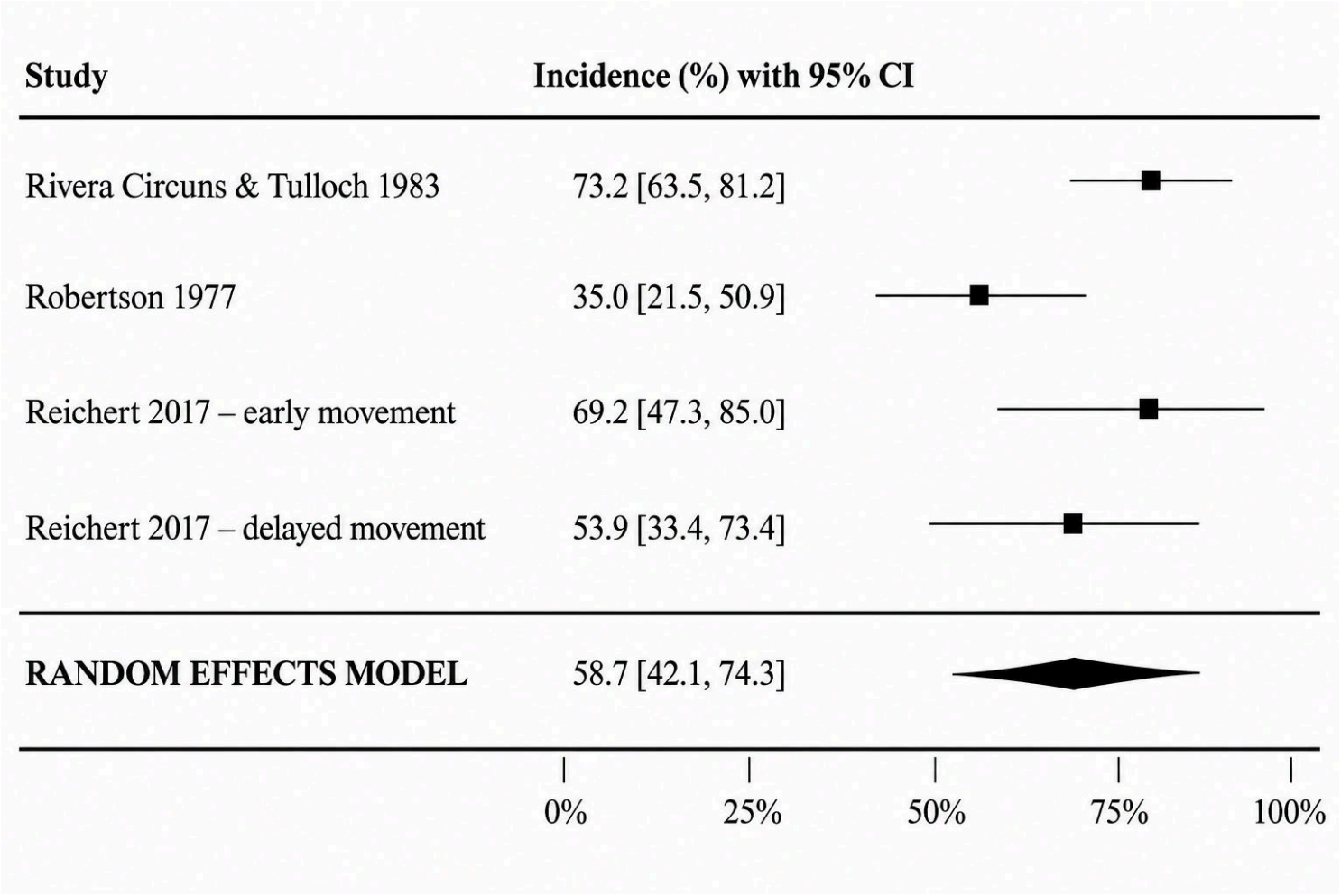

Figure 2

Legend not included with this version.

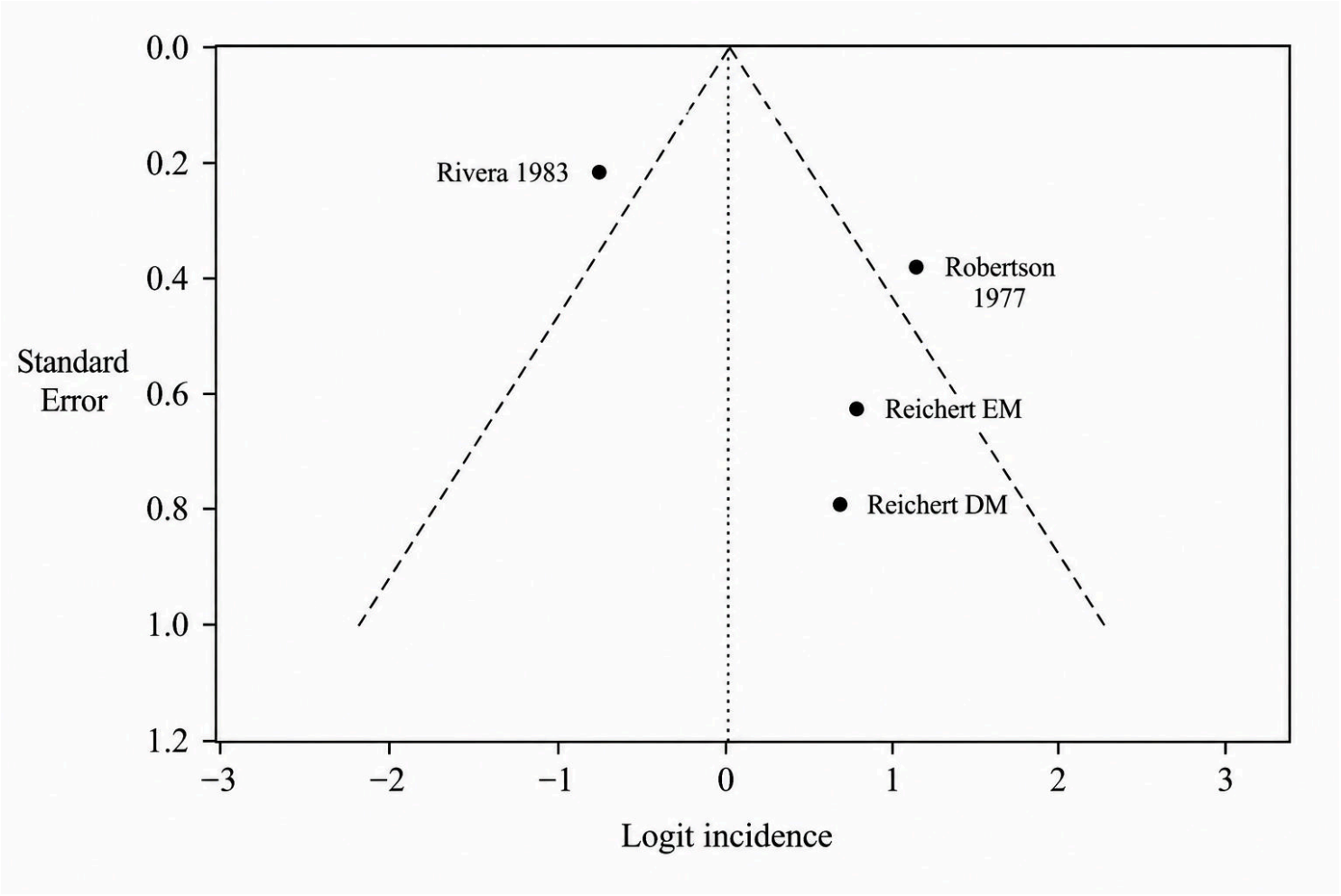

Figure 3

Legend not included with this version.

Supplementary Files

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

- AppendixS1searchstrategies.pdf.docx
- PRISMAScRchecklist.docx
- PRISMA2020checklist.pdf.docx
- SupplementaryTableS1Qualityassessment.xlsx