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Original Article

A mapping review of systematic reviews in orthodontics: a five-year analysis

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Abstract

Objectives: This mapping review aimed to identify trends, frequently reviewed topics and assess the methodological quality of recent orthodontic systematic reviews (SRs).

Methods: SRs published between January 2018 and June 2023 were retrieved from PubMed, EMBASE, SCOPUS, Web of Science, and Google Scholar. Two reviewers independently selected studies and extracted data, with a third resolving discrepancies. Methodological quality was evaluated using AMSTAR-2.

Results: From 3,131 initial articles, 430 SRs were included. A publication increase of over 50% occurred from 2019 to 2022. The most frequent topics were palatal expansion (12.6%), techniques to accelerate orthodontic movement (11.6%), and clear aligners (9.3%). Only 18.2% of SRs were rated as high or moderate quality, with those on clear aligners rated the lowest (4.9%). Common methodological weaknesses included a lack of protocol registration, absence of excluded study lists, and failure to address publication bias.

Conclusions: Orthodontic SRs have increased significantly over the five-year period assessed, with notable increase in contributions from specific countries. However, most SRs exhibited low methodological quality, raising concerns about clinical applicability. Improved adherence to methodological and reporting standards is crucial for enhancing SR quality and credibility.

Keywords: Orthodontics; Systematic Review; Mapping review; Quality assessment

Introduction

Systematic reviews (SRs) are considered at the pinnacle of scientific evidence due to their rigorous methodological approach and comprehensive synthesis of existing studies. However, developing a well-conducted SR requires a complex task, requires both a high level of methodological expertise and in-depth knowledge of the subject matter [1–4]. Unlike clinical studies, SRs do not involve the risk of sample loss or direct patient care, making them relatively low-cost endeavors compared to primary research [5, 6].

SRs often receive substantial citations and are published in high-impact journals [7]. This growing recognition and influence likely contribute to the increasing number of SRs published yearly, reflecting the expanding reliance on evidence synthesis in modern scientific research [8, 9].

Authors sometimes overlook crucial methodological steps to submit SRs quickly [10, 11]. This rush to publication can result in SRs that fail to adhere to appropriate SR methodology. Page et al. [6] reported that despite the dramatic increase in SRs indexed in MEDLINE, many of these reviews failed to report essential methodological elements. These omissions included key aspects such as the database search strategy, data extraction processes, protocol registration, funding sources, and risk of bias assessments. This lack of transparency undermines the reliability and reproducibility of SRs, which are meant to synthesize evidence rigorously and transparently.

As a result, these SRs may introduce biases in synthesizing scientific evidence, which can produce questionable conclusions and overlapping findings and ultimately contribute to research waste [12–14]. This compromises the integrity and utility of the evidence base, making it difficult for clinicians and researchers to rely on these reviews for informed decision-making.

The Assessment of Multiple Systematic Reviews (AMSTAR-2) based on the original AMSTAR with 16 domains has been developed to assess all critical aspects of SRs critically. Unlike its first version (AMSTAR), AMSTAR-2 evaluates the potential impact of SR weaknesses rather than generating an overall score. It is designed for RCT

and non-RCT SRs and aligns with the PICO framework [15, 16].

Awareness of the frequency with which SRs on orthodontic interventions suffer from poor methodological approaches is crucial for those applying their findings in informed clinical decision-making. Mapping research areas is a key first step in this process, particularly given the rapid technological, methodological, and conceptual advancements in orthodontics. This mapping exercise helps better understand the impact of the increasing volume of SRs, identify the most extensively studied topics, and alert clinicians.

Based on this background, we developed a mapping review study of SRs focused on interventions in the field of orthodontics, published over the past five years. The aim was to identify trends in publication and the most frequently reviewed topics within the field and assess the methodological quality of those SRs. By addressing these objectives, the study seeks to provide insights into the current landscape of SRs in orthodontics and highlight areas that have received significant research attention.

Materials and methods

Ethics approval

As the collected primary data was obtained from published studies, no ethics approval was needed.

Eligibility criteria

The present study included all SRs related to orthodontic interventions published between July 2018 and June 2023. To be eligible for inclusion, studies had to address at least one component of the PICO framework (Population, Intervention, Comparison, Outcome) relevant to orthodontics as follows: P—Patients undergoing orthodontic treatment, I—Any intervention that involves orthodontics, C—Any other orthodontic intervention or appliance, no treatment, or placebo, O—Domains listed as Core Outcome Sets [17]. No protocol was registered.

The selection process was conducted in two phases using distinct eligibility criteria:

Phase 1 (title and abstract screening)

Publications were initially screened based on their titles and abstracts. Any publication that identified itself as a SR or employed a systematic approach to identify, select, and appraise studies to answer a specific research question was included in the review. This phase aimed to filter out irrelevant studies and focus on those that met the foundational criteria for systematic evidence synthesis.

Phase 2 (full-text screening)

Full-text articles were screened based on the eligibility criteria outlined in Phase 1, with an additional criterion introduced to ensure adherence to Cochrane's definition of a systematic review (SR). According to the Cochrane Handbook [18], an SR must collate studies meeting pre-specified eligibility criteria to answer a specific research question, minimize biases by searching at least two databases, assess the methodological quality of the included studies, and involve at least two reviewers in each phase of the review process.

Publications that did not meet these criteria were excluded, along with non-interventional SRs, SRs outside the field of orthodontics, overview/umbrella reviews, retracted articles, and supplementary data. This phase ensured only methodologically fit and relevant SRs were included for further analysis.

Search strategy

In collaboration with an expert librarian, a comprehensive search strategy (**Supplementary Table 1**) was developed and executed across multiple databases, including MEDLINE (via PubMed), Embase (via Ovid), Scopus (Elsevier), and Web of Science. Additionally, a complementary search was conducted using Google Scholar. Hand searches of the included studies' reference lists were also performed to ensure thoroughness. This multi-pronged approach aimed to capture all relevant SRs within the defined time frame and enhance the comprehensiveness of the review.

Study selection and data extraction

Two investigators (V.L. and C.S.) independently screened the titles to identify studies related to orthodontics and remove duplicates. Following this, the abstracts of potentially relevant articles were reviewed, and those that met the inclusion criteria were selected for full-text reading. Based on the information from titles and abstracts, studies that could be included underwent a full-text assessment. Any disagreements were resolved through discussion with a third investigator (C.F.). In this phase, the Rayyan software [19] was used to facilitate the screening process.

After identifying the included studies, four reviewers (V.L., M.T., L.S., and C.S.) performed the data extraction using Covidence software [20]. Four reviewers independently extracted data from ten systematic reviews (SRs) for calibration to ensure consistency. Discrepancies were resolved through discussion and refinements to the extraction criteria. This iterative process continued until an agreement of more than 80% was reached. A Microsoft Excel® (Microsoft, CA, USA) spreadsheet was used to organize the information extracted (**Supplementary Table 2**) from the studies [16, 21].

Data on the journal and year of publication were collected according to the citation records available in the databases at the time of the search. Each paper was classified by its main topic based on the intervention described. They were classified under all relevant topics to accurately reflect the scope of systematic reviews (SRs) addressing multiple issues. This approach ensured that multidisciplinary or overlapping reviews were appropriately included in the analysis.

Moreover, the country of publication was determined from the corresponding author's address. These data were then organized into tables and graphs to provide a comprehensive, descriptive presentation of the findings.

Methodological quality assessment

For critical methodological assessment, each study was classified in one or more topics based on the described intervention. Two reviewers (V.L. and C.S.) independently assessed the SR methodology of the three most researched topics using the AMSTAR-2 tool [16]. Each of the 16 domains were answered 'yes' or 'no'. In addition, a 'partial yes' response can be provided in some instances where a partial adherence to the standard is worthwhile to be identified. Critical vs. non-critical domains listed on Table 1.

One researcher interpreted previously extracted AMSTAR-2 data and recorded the corresponding overall

Table 1. Summary of AMSTAR-2 critical and non-critical domains (quality assessment)

Critical Domains	Non-critical Domains
• Did the systematic review report contain an explicit statement that the review methods were established before the conduct of the review, and did the report justify any significant deviations from the protocol? • Did the systematic review authors use a comprehensive literature search strategy? • Did the systematic review authors provide a list of excluded studies and justify the exclusion? • Did the systematic review authors use a satisfactory technique for assessing the risk of bias in individual studies included in the systematic review? • If meta-analysis was performed, did the systematic review authors use appropriate methods for statistical combination of results? • Did the systematic review author account for the risk of bias in primary studies when interpreting/discussing the systematic review results? • If they performed quantitative synthesis, did the systematic review authors carry out an adequate investigation of publication bias and discuss its likely impact on the systematic review synthesis?	• Did the research question and inclusion criteria for the systematic review include PICO components (Population, Intervention, Control Group, Outcome)? • Did the systematic review authors explain their selection of the study designs for inclusion in the systematic review? • Did the systematic review authors perform study selection in duplicate? • Did the systematic review authors perform data extraction in duplicate? • Did the systematic review authors describe the included studies in adequate detail? • Did the systematic review authors report on the funding sources for the studies included in the review? • If meta-analysis was performed, did the systematic review author assess the potential impact of risk of bias in individual studies on the results of the meta-analysis or other evidence synthesis? • Did the systematic review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the review results? • Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?

Table 2. Interpretation scheme for the AMSTAR-2 domains (quality assessment)

	Concept			
	High	Moderate	Low	Critically Low
Characteristic	None or one non-critical weakness.	More than one non-critical weakness.	One critical flaw with or without non-critical weakness.	More than one critical flaw with or without non-critical weakness.
Interpretation	The SR provides an accurate and comprehensive summary of the results from the available studies that address the question of interest.	The SR has more than one weakness but no critical flaw. It may provide an accurate summary of the results of the available studies that were included in the review.	It may not provide an accurate and comprehensive summary of the available studies that address the question of interest.	The SR should not be relied on to provide an accurate and comprehensive summary of the available studies.

rating for each systematic review in a Microsoft Excel® spreadsheet, following the criteria presented in the AMSTAR-2 interpretation Table 2. The number of publications per topic was also documented in the same spreadsheet.

Descriptive analysis was used to summarize the yearly number of SRs published and their average AMSTAR-2 scores.

Results

Of the initial 3,131 articles, 514 were sought for full-text retrieval. After excluding 84, 430 were ultimately included in the review. **Figure 1** illustrates the SR selection and exclusion process and outlines the reasons for exclusion. **Supplementary Table 3** provides detailed explanations for excluding the 84 articles.

Figure 2 presents the number of SRs published between the second semester of 2018 and the first semester of 2023, segmented into six-month periods. The results show a consistent increase in the number of SRs over time. In the second half of 2018, 31 SRs were published. This number grew modestly in the following periods, reaching 37 in the first half of 2019 and 32 in the second half 2019. The upward trend continued, with 37 publications in the first half of 2020, 38 in the second half of 2020, and 39 in the first half of 2021.

A notable acceleration in publication numbers occurred from the second half of 2021 onward, with 51 SRs published in 2021.2, 49 in 2022.1, and 56 in 2022.2. The peak was observed in the first half of 2023, with 60 SRs published.

During the mapped period, China emerged as the leading contributor to SRs in orthodontics; Brazil, India, the United States, and Switzerland followed. These contributions are visualized in **Figure 3**, which highlights the significant contributions of these countries to orthodontic research and provides insight into the global distribution of academic efforts in the field.

The orthodontic intervention topics with the highest number of SRs published during the analyzed period reflect the current focus areas within the field. Palatal expansion (PE) ranked the most frequently studied topic, accounting for 12.6% of all SRs. Following closely were techniques aimed at accelerating orthodontic tooth movement (TA), representing 11.6% of the publications. Clear aligners (CA), a rapidly growing area in orthodontics due to their aesthetic and functional appeal, comprised 9.3% of the SRs. Mini-screws/

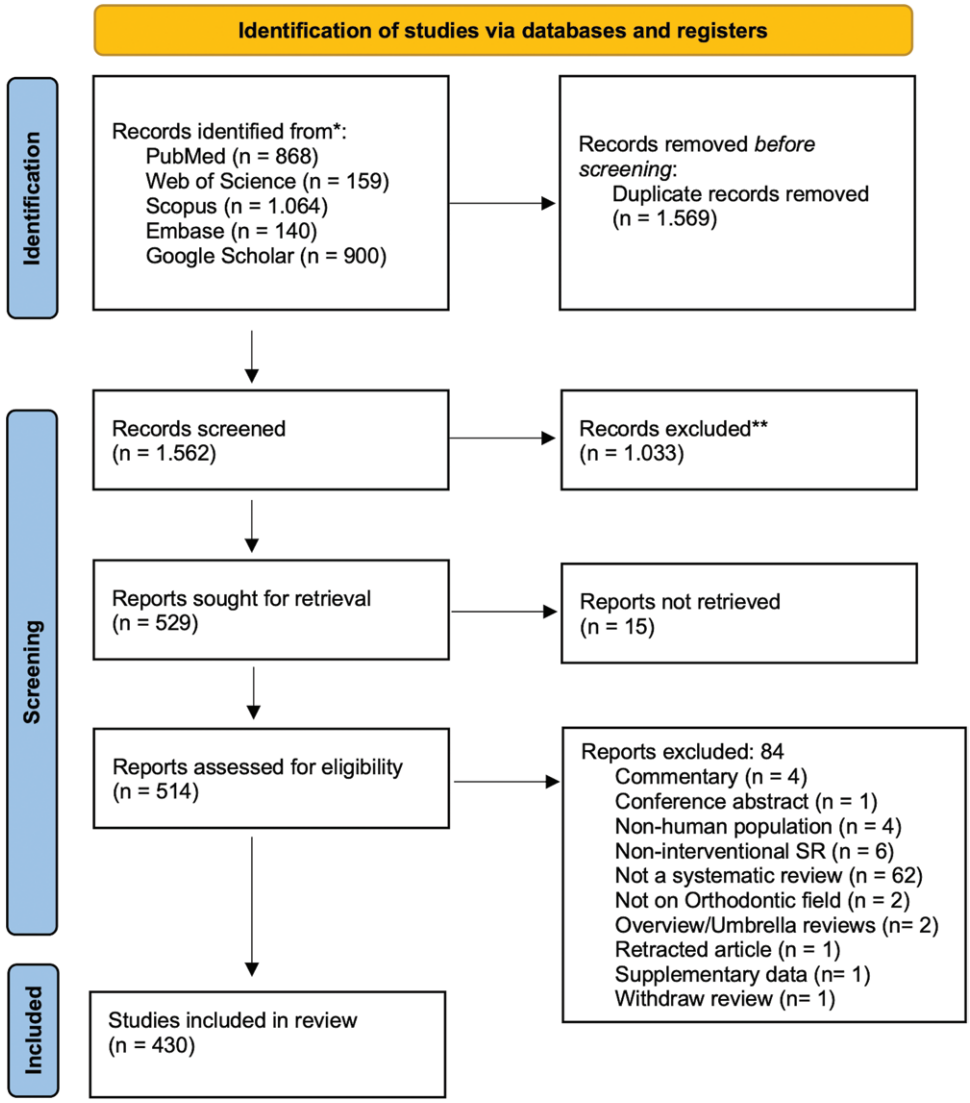

Figure 1. Systematic search flow diagram.

TADs, often used to provide anchorage in complex orthodontic treatments, were the focus of 5.8% of the studies. Finally, maxillary protraction, a critical intervention for correcting maxillary complex deficiency skeletal discrepancies, accounted for 5.1% of the SRs. These findings, illustrated in Figure 3, underscore the diverse orthodontics research priorities and the scientific community's evolving interests in addressing key clinical challenges.

Table 3 details annual publication numbers and average AMSTAR-2 methodological quality scores for the three most explored topics. For PE SRs, approximately 44% were rated Critically Low, with 26% Low, 22% Moderate, and 7% High. The percentage of Critically Low SRs fluctuated significantly during the study period (July 2018 to June 2023), ranging from 20% in 2019 to 60% in 2022.

Regarding TA, 2022 saw the most SRs (14 reports), the highest percentage of High AMSTAR-2 ratings (28.6%), and the lowest percentage of Critically Low SRs (35.7%). However, 60.4% of TA SRs were rated Critically Low, contrasting sharply with the 12.5% rated High.

Less than 5% of CA SRs were rated above Low. Excluding 2020, only Low or Critically Low SRs were published for CA. The highest percentages of Critically Low CA SRs were observed in 2021 and 2022 (80%), followed by 2019 (75%), 2020 and 2023 (60% each), and 2018 (50%).

Figure 4 displays the frequency of 'No' responses for each AMSTAR-2 item across the three topics. For CA, items 10 (35 times), 7 (30 times), and 14 (26 times) had the highest 'No' response rates. In the TA, items 10 (44 times) and 7 (23 times) were the most problematic. For PE, items 10 (53 times) and 7 (27 times) showed the highest 'No' response rates. Item 10 consistently received high 'No' responses across all topics, indicating a widespread quality concern. Overall, items 10 (132 times), 7 (80 times), and 14 (61 times) were the more neglected.

Discussion

SRs are valuable tools for synthesizing the most current and high-quality evidence. Mapping studies is a valued tool for analyzing publication trends within a specific field, identifying research topics that have been explored, and guiding researchers in pinpointing areas that still require investigation.

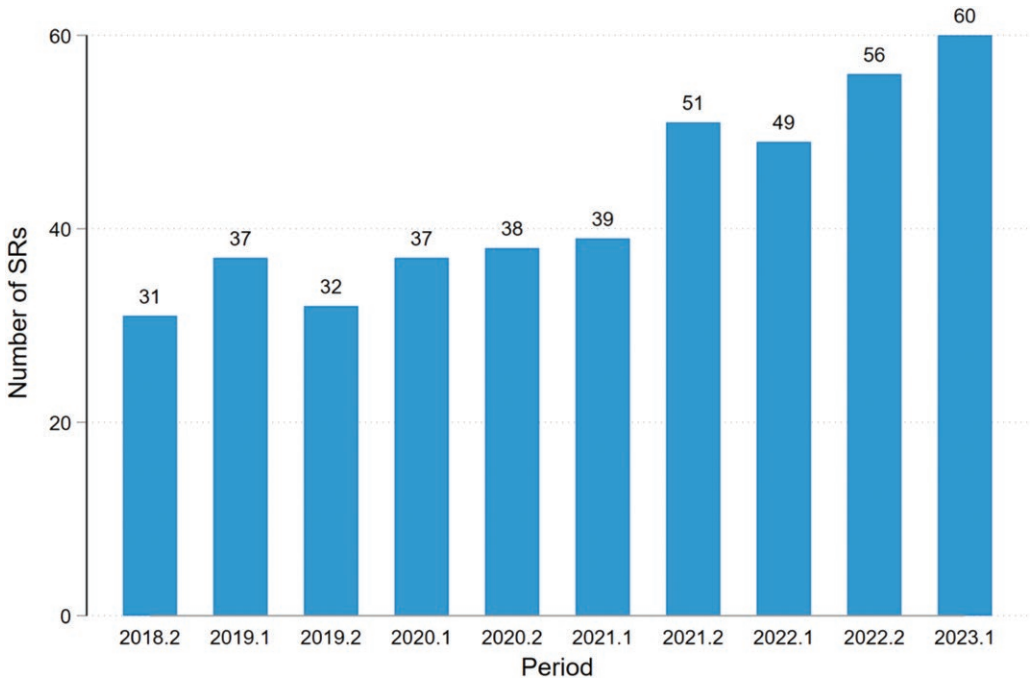

Figure 2. Number of publications from the second semester of 2018 to the first semester of 2023.

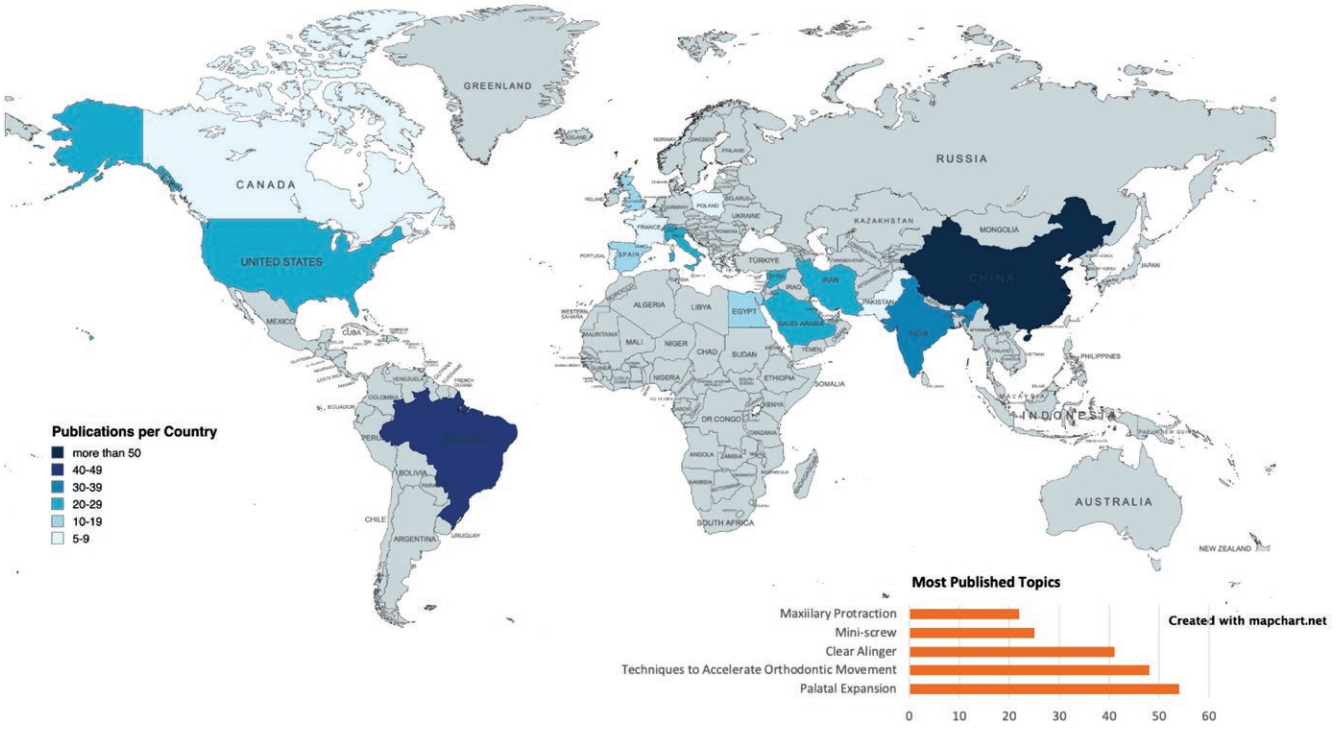

Figure 3. Publication per country and topic.

Given the substantial growth in orthodontic SRs, this mapping review is important for understanding the field's current state. Unlike scoping or bibliometric reviews, this study aimed to identify trends, frequently addressed topics, and extensively studies areas in the orthodontic literature [8, 22].

Therefore, this study quantified the number of SRs related to orthodontic interventions from July 2018 to June 2023. While some orthodontic bibliometric data have been published previously, these studies often focused on citation patterns or were limited to a small selection of orthodontic journals [23–25]. In contrast, the present study did not impose any limitations on the journals considered, conducting a broad search across the entire literature for orthodontic-related publications. This inclusive approach allowed for a more comprehensive overview of the SRs in orthodontics, offering a clearer picture of trends and research priorities within the field.

Table 3. AMSTAR-2 Quality Assessment of Systematic Reviews published about the 3 most explored topics in Orthodontics

Year	Palatal Expansion (PE)					Techniques to Accelerate Orthodontic Movement (TA)					Clear Aligner (CA)				
	High	Moderate	Low	Critically Low	Total	High	Moderate	Low	Critically Low	Total	High	Moderate	Low	Critically Low	Total
2018	0 (0%)	2 (40%)	1 (20%)	2 (40%)	5 (100%)	0	0	1 (50%)	1 (50%)	2 (100%)	0	0	1 (50%)	1 (50%)	2 (100%)
2019	1 (20%)	1 (20%)	2 (40%)	1 (20%)	5 (100%)	0	0	1 (12.5%)	7 (87.5%)	8 (100%)	0	0	1 (25%)	3 (75%)	4 (100%)
2020	0	2 (28.6%)	1 (14.3%)	4 (57.1%)	7 (100%)	1 (10%)	1 (10%)	2 (20%)	6 (60%)	10 (100%)	2 (20%)	0	2 (20%)	6 (60%)	10 (100%)
2021	1 (6.7%)	4 (26.7%)	5 (33.3%)	5 (33.3%)	15 (100%)	0	0	1 (16.7%)	5 (83.3%)	6 (100%)	0	0	1 (20%)	4 (80%)	5 (100%)
2022	2 (13.3%)	2 (13.3%)	2 (13.3%)	9 (60%)	15 (100%)	4 (28.6%)	1 (7.14%)	4 (28.6%)	5 (35.7%	14 (100%)	0	0	2 (20%)	8 (80%)	10 (100%)
2023	0	1 (14.3%)	3 (42.8%)	3 (42.8%)	7 (100%)	1 (12.5%)	0	2 (25%)	5 (62.5%)	8 (100%)	0	0	4 (40%)	6 (60%)	10 (100%)
2018-2023	4 (7.4%)	12 (22.2%)	14 (25.9%)	24 (44.4%)	54 (100%)	6 (12.5%)	2 (4.17%)	11 (22.9%)	29 (60.4%)	48 (100%)	2 (4.9%)	0	11 (26.8%)	28 (68.3%)	41 (100%)

Building upon a previous study [22] examining orthodontic SR trends, this mapping review expands the scope by analyzing SRs from multiple sources, surpassing the limitations of Cochrane-only analyses. This research identifies frequently reviewed topics, publication trends, and areas with limited exploration.

The number of published SRs in orthodontics has nearly doubled from 2019 to 2022 (**Figure 2**), reflecting a broader trend observed in the field of dentistry overall [26], where the proportion of SRs increased from 5.8% to 53.3% during this period. As expected, orthodontic journals dominate the list of top periodicals publishing SRs related to orthodontic interventions (Table 4). The full list with all the Journals can be found in Supplementary Table 4. However, it is notable that three journals that did not exclusively focus on orthodontics were also among the top publishers of SRs in the field. This suggests that orthodontic research is increasingly being published in journals outside the specialty, potentially reflecting the interdisciplinary nature of modern orthodontic practice [27]. This trend may also be due to orthodontic journals' relatively smaller impact factors, prompting authors to submit their work to higher-impact journals [28]. This emphasizes the importance of conducting a mapping study that does not impose limitations based on journal focus, as it provides a more comprehensive view of where orthodontic research is being disseminated and underscores the need for cross-disciplinary publication in the field.

China, Brazil, and India emerged as the leading countries regarding the number of SRs published in orthodontics during the examined period, a trend also observed in recent bibliometric studies [26, 29]. The United States ranked fourth, consistent with previous research [27] that suggests a country's large size and the number of research centers and researchers can contribute to a higher volume of publications.

In addition to that, this study reveals a significant publication surge during the second semester of 2021. In previous periods, the number of SRs ranged from 31 to 39 publications per semester, but in the second half of 2021, 51 SRs were published. One possible explanation for this spike is the COVID-19 pandemic and its impact on conducting clinical studies. While clinical research faced substantial restrictions during this time, SRs could still be undertaken without such limitations. To understand the reliability of synthesized evidence and its clinical impact, future research must explore if SRs published during this period adhered to the same methodological standards as those from non-pandemic years. Assessing the impact of external factors on SR quality is critical. Additionally, during 2020, there was a notable increase in the use of cloud services, international collaboration, and remote meetings. Additionally, clinical research funding was often redirected to COVID-related studies, and many clinical trials were suspended due to reduced or limited access to healthcare research infrastructures [30]. These factors likely contributed to the increased output of SRs during this period.

This research contributes to understanding orthodontics' more frequently synthesized areas and their methodological limitations and highlights areas needing high-quality studies. With the growing need for reliable evidence to guide clinical practice, fostering robust primary research and optimizing SR resource use is vital [22, 29].

Rapid palatal expansion (PE), or rapid maxillary expansion, was the most frequently researched intervention, which

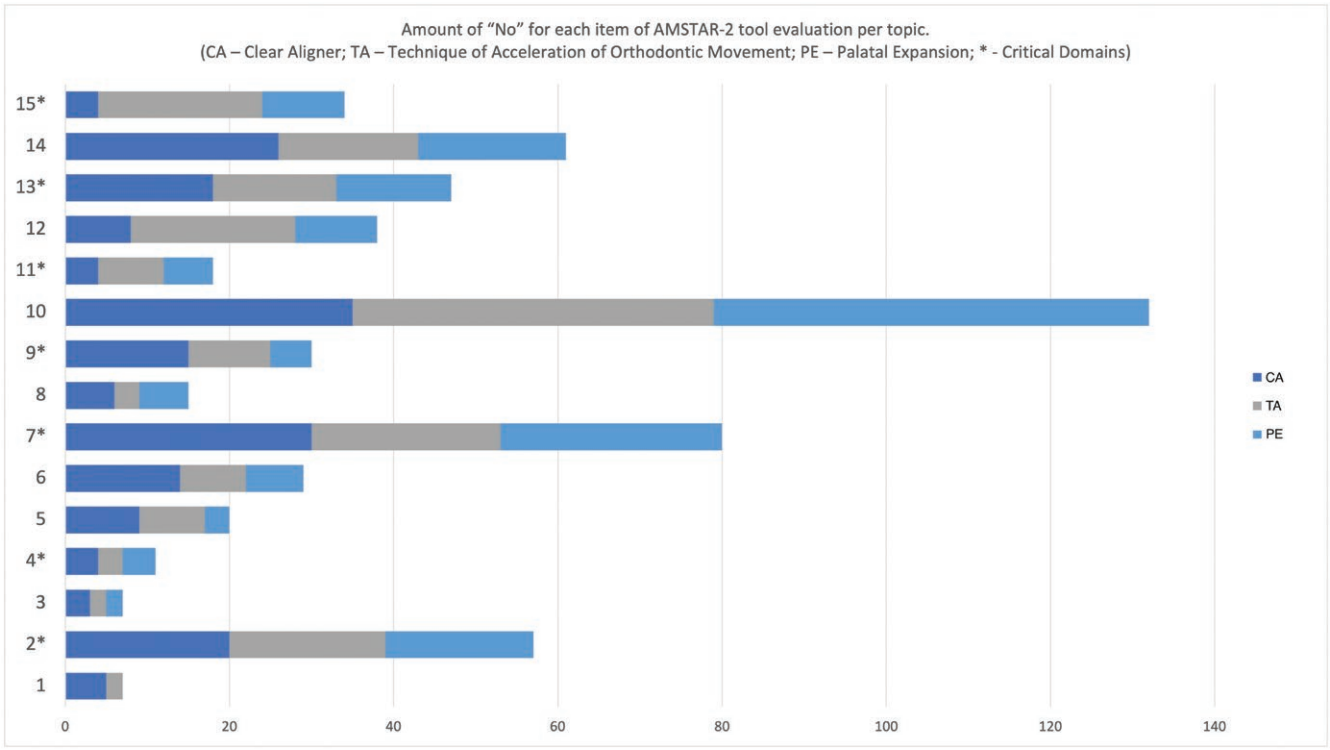

Figure 4. AMSTAR-2 evaluation—number of 'No' ratings per item.

Table 4. Top-10 Journals with more Systematic Reviews in the orthodontic field published from July 2018 to June 2023

Journal	n	%
European Journal of Orthodontics	40	9.30
Orthodontics and Craniofacial Research	27	6.28
International Orthodontics	25	5.81
American Journal of Orthodontics and Dentofacial Orthopedics	16	3.72
The Angle Orthodontist	16	3.72
BMC Oral Health	11	2.56
Australasian Orthodontic Journal	10	2.33
Progress in Orthodontics	10	2.33
Cureus	8	1.86
Journal of Clinical Medicine	8	1.86

is unsurprising given the extensive literature on the topic. The recent rise in popularity of Mini Screw Assisted Rapid Palatal Expansion (MARPE) may have further fueled interest in this area. Several recent clinical studies on MARPE have been conducted, highlighting the need to synthesize new primary data through SRs [31]. Additionally, PE is a routine technique in orthodontic practices, known for its high predictability and favorable prognosis when correctly indicated [32]. This widespread clinical application likely contributes to the high demand for up-to-date information on the technique.

Following that, the large number of SRs related to TA should come as no surprise. Various methods and techniques are available for accelerating orthodontic tooth movement, and comparing these approaches and evaluating their effectiveness is crucial [33, 34].

Conversely, the significant number of SRs focusing on CAs may be more remarkable. While the growing popularity of clear aligners in orthodontic practice can explain much of the interest in this topic, given that clear aligners are a more recent technique, there is a relatively limited number of clinical studies on them. Thus, the identified volume of SRs on clear aligners is somewhat unexpected. It was initially anticipated that fewer SRs would be published as the evidence body was still evolving [27, 35].

However, it is essential to recognize that securing publication space in high-impact journals can become challenging when topics are widely explored, like those mentioned above. The saturation of publications on these subjects often leads to diminished interest from more selective journals. In such cases, researchers may submit their SRs to less selective journals or journals from other disciplines that accept a broader range of topics. Therefore, while publishing in high-impact journals is ideal, the realities of the scientific field often require flexibility. Factors such as publication deadlines and costs can further influence this decision [9, 29].

At first glance, these data may seem promising, as the growing number of SRs suggests an expansion of high-quality evidence, potentially improving the quality of available knowledge [28]. When using AMSTAR-2, most SRs across the most explored topics were rated Critically Low, raising significant concerns about validity and usefulness. Although a significant proportion of systematic reviews (SRs) received 'yes' or 'partial yes' responses, the overall evaluation was undermined by missing critical elements. These results are concerning, given the critical influence of SRs on clinical decision-making and public health policy [16].

The lack of excluded study lists and justifications (item 7) was a critical flaw across all topics, affecting 30 of the CA, 23 of the TA, and 27 of the PE SRs. This omission hinders transparency and limits the interpretability of findings. The absence of a pre-defined research protocol (item 2) was also a significant issue, particularly in PE (18 times) and CA (20 times) SRs. Protocol development is essential for reducing bias and improving transparency [16, 36].

Meta-analysis (MA) was conducted in only 10 (24.4%) CA SRs, compared to 24 (44.4%) for PE and 31 (56.25%) for TA. A concerning 80% of CA MAs did not address risk of bias. Additionally, 41.67% of TA and 18.52% of PE SRs failed to investigate publication bias, consistent with previous findings that 38% of non-Cochrane SRs inadequately report risk of bias (RoB), highlighting a critical gap in CA SRs (14 reports). While meta-analysis requires homogeneity among included studies, only 23% (CA), 47.62% (TA), and 53.33% (PE) of SRs without MAs investigated heterogeneity in the included studies. This suggests CA may necessitate more and better primary research before conducting additional SRs.

Furthermore, despite the increase in SRs, there has been a decline in the total number of primary studies in orthodontics [23]. This observation raises significant concerns about the reliability of the published SRs, as their conclusions heavily depend on the quality and quantity of the primary studies they synthesize. Given that the number of primary studies is decreasing, it seems paradoxical that the number of SRs is simultaneously rising. This discrepancy highlights a potential issue: the increasing volume of SRs may be built on a shrinking pool of primary research, which could affect the robustness and generalizability of the findings. This further underscores the need for careful scrutiny of both the methodological quality of SRs and the underlying primary studies they are based on.

Conclusions

Over the evaluated five-year period, published orthodontic SRs increased. However, the methodological quality was predominantly low, with few SRs rated moderate or high.

Seven of the ten journals publishing the most orthodontic intervention SRs were dedicated orthodontic journals.

Developing countries, especially China, Brazil, and India, contributed significantly to orthodontic intervention SRs.

Palatal expansion was the most frequently reviewed topic, followed by techniques to accelerate orthodontic tooth movement and clear aligners. Palatal expansion had the highest proportion of moderate or high-quality assessments. Techniques for accelerating orthodontic movement followed, while clear aligners had the lowest methodological quality.

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Conflict of Interest

The authors declare that they have no financial interests, connections, or relationships, direct or indirect, that could be perceived as a conflict of interest concerning the work reported in this publication. There are no pertinent commercial or other sources of funding associated with this research, and they have no personal relationships or direct academic competition that could compromise the perception of impartiality. This declaration is made to ensure transparency and maintain the integrity of the work presented.

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Data Availability

Upon reasonable request to the corresponding author, primary data will be shared.

Supplementary material

Supplementary material is available at *European Journal of Orthodontics* online.

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