

REVIEW ARTICLE

Does the Use of a Bioceramic Sealer Reduce Postoperative Pain Compared With an Epoxy Resin-Based Sealer After Primary Root Canal Treatment and Retreatment?—An Umbrella Review

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ABSTRACT

Background: Postoperative pain (POP) is a frequent occurrence after root canal treatment (RCT). There is conflicting evidence regarding the prevalence of POP after root canal filling with a bioceramic sealer in comparison with an epoxy resin-based sealer.

Objective: To ascertain whether the use of a bioceramic sealer reduces POP in comparison with an epoxy-resin-based sealer in combination with gutta percha following primary RCT and retreatment.

Methods: A literature search was carried out in electronic databases from inception to 20 January 2025. Systematic reviews (SRs) that evaluated the POP using bioceramic sealers when compared with epoxy resin-based sealers were included. The quality of the reviews was evaluated employing the AMSTAR 2 tool. The overall confidence in the findings of the review was categorised as critically low, low, moderate or high.

Results: In total, 13 SRs were included. The POP experienced when bioceramic sealers were used in combination with gutta percha was similar to that of epoxy resin-based sealers. All the SRs adequately addressed Item 1 ('Did the research questions and inclusion criteria for the review include the components of PICO?'). Only one SR adequately addressed Item 3 ('Did the review authors explain their selection of the study designs for inclusion in the review?') and Item 10 ('Did the review authors report on the sources of funding for the studies included in the review?'). The overall confidence in the findings of ten, two and one SR(s) was classified as 'critically low', 'low' and 'high', respectively.

Conclusion: Based on current evidence, it can be concluded that root canal filling with a bioceramic sealer demonstrated POP that was comparable to that of epoxy resin-based sealers following primary RCT and retreatment. As per the recommendations in this umbrella review regarding the methodological quality of existing SRs, high-quality SRs are necessary in the future.

Trial Registration: PROSPERO database: CRD42024616520

[Corrections added on 17 February 2026, after first online publication: the co-author's name has been updated from 'Jelena Jacomovic' to 'Jelena Jacimovic' in this version.]

1 | Introduction

A primary concern for both patients and clinicians after root canal treatment (RCT) is the prevalence and severity of postoperative pain (POP) (Montero et al. 2015; Sathorn et al. 2008). A previous systematic review (SR) indicated that the prevalence of POP after RCT was common ranging from 3% to 58% (Sathorn et al. 2008). A patient's quality of life is clearly influenced by POP (Oliveira et al. 2019).

Root canal filling generally involves the use of gutta percha and a root canal sealer. Gutta percha possesses no adhesive qualities, so a sealer is essential for the establishment of a fluid-tight seal in the root canal, as it occupies the empty space between the core filling material and the prepared dentine wall (Darcey et al. 2016). In daily practice, endodontists widely use epoxy resin-based sealers such as Radic-SEaler (KM, Seoul, Korea), AH-plus (Dentsply DeTrey, Konstanz, Germany) etc., due to their excellent physical properties, sealing ability and long track record in clinical practice (Álvarez-Vásquez et al. 2024; Lim et al. 2020).

Endodontists have recently increased their use of hydraulic calcium silicate cement sealers, which are often termed as bioceramic due to their bioactive stimulation during periapical region repair, their antimicrobial and biocompatible properties and their ability to set even in moist conditions (Benetti et al. 2019; Chang et al. 2014; Dong and Xu 2023; Lee et al. 2019; Zavattini et al. 2020). They are categorised according to their clinical application, the percentage of bioactive calcium silicate or the composition and formulation, such as powdered form, liquid, paste-to-paste or premixed (Camilleri 2020; Cardinali and Camilleri 2023; Primus et al. 2022).

Multiple SRs evaluating POP following primary RCT with bioceramic sealers in combination with gutta percha compared with epoxy resin-based sealers have been published (Chopra et al. 2022; Jamali et al. 2021; Mahajan et al. 2023; Mekhdieva et al. 2021; Mittal et al. 2024; Monteiro et al. 2023; Moraes et al. 2024; Seron et al. 2023; Shaik et al. 2024; Sowmya 2021; Sponchiado Junior et al. 2021; Supare et al. 2024; Zamparini et al. 2024). Several of these SRs concluded that there is no significant difference in POP between epoxy resin-based sealers and bioceramic sealers (Chopra et al. 2022; Jamali et al. 2021; Mahajan et al. 2023; Mittal et al. 2024; Monteiro et al. 2023; Moraes et al. 2024; Shaik et al. 2024; Sowmya 2021; Sponchiado Junior et al. 2021; Supare et al. 2024; Zamparini et al. 2024). However, two SRs have shown the opposite, concluding that bioceramic sealers are associated with less POP when compared with epoxy resin-based sealers (Mekhdieva et al. 2021; Seron et al. 2023). Mekhdieva et al. (2021) claim that bioceramic sealers exhibit lower POP levels in nonvital teeth, and epoxy resin-based sealers exhibit lower POP levels in vital teeth. Seron et al. (2023) carried out a SR, which revealed that the application of bioceramic sealers led to a decrease in both POP and apical extrusion of the sealer within 24 h.

It is becoming increasingly challenging to make evidenced-based clinical decisions due to the growing number of SRs on this subject, their contradictory findings and the variable quality of the reviews published. Therefore, evaluating the quality of published SRs and providing a comprehensive and exhaustive overview of the subject matter is crucial to assist clinicians in

selecting root canal sealers based on pain outcomes. An umbrella review includes the systematic collection and quality appraisal of systematic reviews (SRs) that have been published on a particular research topic in order to offer better evidence as well as a more comprehensive and exhaustive perspective (Aromataris et al. 2015). Umbrella reviews enable the comparison and analysis of findings from various SRs published on the same topic (Aromataris et al. 2015).

The objectives of the current umbrella review were to identify and evaluate the methodologic quality of the published SRs, with or without meta-analysis, and to present a concise summary of the primary findings in order to evaluate the POP following primary RCT and retreatment with bioceramic root canal sealer and gutta percha in comparison with epoxy resin-based sealers and gutta percha.

2 | Methods

2.1 | Protocol Registration and Reporting Guidelines

The protocol of this review was registered a priori in PROSPERO (CRD42024616520). This review reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al. 2021).

2.2 | Review Question

Does the use of a bioceramic sealer reduce POP compared with an epoxy resin-based sealer in combination with gutta percha after primary RCT and retreatment?

2.3 | Selection Criteria

SRs with or without meta-analysis comparing POP following primary RCT and retreatment in adults between bioceramic root canal sealers and epoxy resin-based sealers in combination with gutta percha were included. Narrative review, scoping reviews, case reports/case series, animal/laboratory-based studies and clinical trials were excluded.

2.4 | Literature Search

Two independent reviewers assessed the titles and abstracts to determine their inclusion in the current review. The full text of each SR was reviewed to determine its inclusion in cases of uncertainty following the reading of the abstract and title. A third reviewer assisted in resolving disagreements. If needed, the corresponding author of the current umbrella review contacted the corresponding author of the included SRs to obtain any missing or unclear information.

The search strategy (outlined in Table S1) was framed collaboratively by the full research team, under the guidance of an experienced librarian and information specialist. A thorough literature search was carried out on 26 October 2024, across various

databases, including Clarivate Analytics' Web of Science (covering the Web of Science Core Collection, ProQuest Dissertations & Theses Citation Index, SciELO Citation Index, Korean Citation Index and Grants Index), Scopus, PubMed (including MEDLINE) and the Cochrane Database of Systematic Reviews (Cochrane Library). The search was performed without any language or publication date restrictions. The search approach was peer-reviewed according to the Peer Review of Electronic Search Strategies (PRESS) guidelines (McGowan et al. 2016), and feedback from an additional information specialist was incorporated prior to the final database search. In order to incorporate grey literature, additional resources were investigated, including OpenGrey (<http://www.opengrey.eu>), Google Scholar (the initial 100 results), and various digital repositories. These repositories comprised the Networked Digital Library of Theses and Dissertations (<http://www.ndltd.org>), Open Access Theses and Dissertations (<https://oatd.org>), the DART-Europe E-theses Portal (<https://www.dart-europe.org/basic-search.php>) and EThOS (<https://ethos.bl.uk>). Citation tracking, both backward and forward, was conducted using tools such as WoS, Scopus and Google Scholar to ensure the search was as thorough as feasible. The search was updated towards the end of the manuscript preparation, with a final check on 20 January 2025, to ensure no new relevant SRs had been published since the initial search. An additional search of the PROSPERO register and JBI Evidence Synthesis Reports revealed no ongoing or completed SRs.

2.5 | Data Extraction

Two reviewers independently carried out the data extraction and approached a third reviewer to resolve any discrepancies.

The following data was collected from the reviews that were included: the first author's name and country, the year of publication, the name of the journal, the language, literature search period, whether a meta-analysis was conducted or not, the number and study design of primary studies included the name of the quality assessment tool, the protocol registered database and the source of funding.

2.6 | Methodological Quality and Overall Confidence

Two independent reviewers evaluate each review to evaluate the methodological quality of the reviews and the overall confidence rating in the results using the AMSTAR 2 tool (Shea et al. 2017). In total, AMSTAR 2 has 16 items. Each AMSTAR 2 item was scored by reviewers as 'yes' if it was sufficiently addressed, 'partial yes' if it was partially addressed, and 'no' if it was not addressed. The critical and non-critical domains were used to categorise the overall confidence in the results of each review as 'High', 'Moderate', 'Low' or 'Critically low' (Shea et al. 2017).

3 | Results

3.1 | Literature Search and Characteristics of the Included Studies

Figure 1 shows the PRISMA flowchart. Titles and abstracts were screened, and 15 papers were deemed eligible for full text reading. After the full text reading, two reviews (Küçükaya Eren et al. 2022; Carr and MacInnes 2022) were excluded for

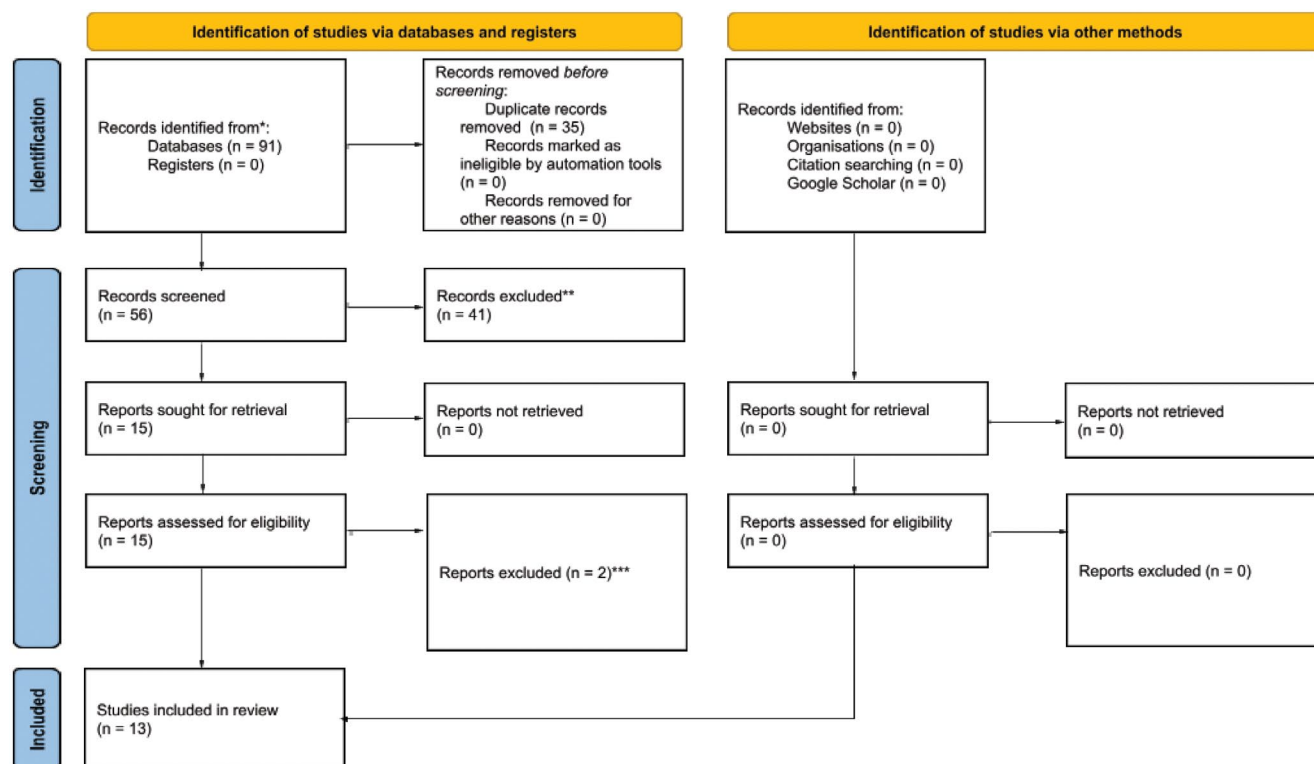


FIGURE 1 | PRISMA 2020 flow diagram. *The number of records identified from each database or register searched is given in Table S1. **Exclusion of records was performed by a human. ***The list of excluded studies and reasons for exclusion are given in Table S2.

TABLE 1 | Characteristics of included systematic reviews.

S. No.	Author, year	Name of the journal published	Country of the first author	Search period	Meta-analysis performed	Number of studies included	Risk of bias tool	Protocol registered	Source of funding
1	Mekhdieva et al. (2021)	Journal of Clinical Medicine	Italy	January 2010 to January 2021	Yes	9	Cochrane risk of bias tool	PROSPERO	None
2	Jamali et al. (2021)	Pesquisa Brasileira em Odontopediatria e Clínica Integrada	China	2015 to 2020 September	Yes	4	Cochrane risk of bias tool	Not reported	None
3	Sponchiado Junior et al. (2021)	European Journal of Dentistry	Brazil	Until November 2020	Yes	5	JBIR tool	PROSPERO, Open Science framework	Public funding agency, Coordination of Improvement of Higher Education Personnel of the Ministry of Education (CAPES), for support by PROCAD notice (grant number: 88887.473221/2020-00) and PROEX (grant number: 001)
4	Sowmya (2021)	International Journal of Dentistry and Oral Science	India	Not reported	No	6	Cochrane risk of bias tool	Not reported	Not reported
5	Chopra et al. (2022)	Journal of Functional Biomaterials	London	January 2011 to December 2021	Yes	12	Cochrane risk of bias tool, Methodological index for non-randomised studies (MINORS)	PROSPERO	None
6	Seron et al. (2023)	Odontology	Brazil	Until April 2023	Yes	18	Cochrane risk of bias tool (RoB 2.0)	PROSPERO	Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brasil (CAPES)—Finance Code 001

(Continues)

TABLE 1 | (Continued)

S. No.	Author, year	Name of the journal published	Country of the first author	Search period	Meta-analysis performed	Number of studies included	Risk of bias tool	Protocol registered	Source of funding
7	Mahajan et al. (2023)	Journal of Pharmacy and Bioallied Sciences	India	Until December 2022	No	7	Four criteria: randomisation, allocation concealment, assessor blinding and completeness of follow-up	Not reported	None
8	Monteiro et al. (2023)	Restorative Dentistry and Endodontics	Brazil	Until December 2020	Yes	9	Cochrane risk of bias tool (RoB 2)	PROSPERO	Not reported
9	Zamparini et al. (2024)	International Endodontic Journal	Italy	2007 to October 2023	Yes	15	Cochrane risk of bias tool (RoB 2), Modified version of the Downs and Black checklist	PROSPERO	None
10	Moraes et al. (2024)	Brazilian Dental Sciences	Brazil	Until September 2021	Yes	12	Cochrane risk of bias tool (RoB 2)	PROSPERO	FAPERJ—Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro [#E- 26/010.100995/2018; #E-26/202.805/2019; #E-26/010.002195/2019], CNPQ (Conselho Nacional de Desenvolvimento Científico e Tecnológico), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brasil (CAPES)-Finance Code 001
11	Mittal et al. (2024)	Dental and Medical Problems	India	Until November 2021	No	10	Cochrane risk of bias tool (RoB 2)	Not reported	None

(Continues)

TABLE 1 | (Continued)

S. No.	Author, year	Name of the journal published	Country of the first author	Search period	Meta-analysis performed	Number of included studies	Risk of bias tool	Protocol registered	Source of funding
12	Shaik et al. (2024)	Journal of Pharmacy and Bioallied Sciences	United States	January 2018 to February 2023	Yes	5	Not reported	Not reported	None
13	Supare et al. (2024)	Peer J	India	January 2000 to August 2022	Yes	9	Cochrane risk of bias tool (RoB 2)	PROSPERO	Deanship of Scientific Research at King Khalid University, Abha, Saudi Arabia, through the Large Research Group Project under grant number (RGP.2/469/45)

different reasons (Table S2). In total, 13 reviews were included and published between 2021 and 2024 (Chopra et al. 2022; Jamali et al. 2021; Mahajan et al. 2023; Mekhdieva et al. 2021; Mittal et al. 2024; Monteiro et al. 2023; Moraes et al. 2024; Seron et al. 2023; Shaik et al. 2024; Sowmya 2021; Sponchiado Junior et al. 2021; Supare et al. 2024; Zamparini et al. 2024). Table 1 illustrates the characteristics of the included reviews. Of the 13 included SRs, 10 were coupled with meta-analysis. Among 13 SRs, the protocol was registered in eight SRs, with seven of these SRs being registered in the PROSPERO database and one SR being registered in both the PROSPERO and Open Science framework databases. It was not registered in five SRs (Table 1).

3.2 | Main Findings

Of the 13 SRs, 11 reported that there is no significant difference between bioceramic sealers and epoxy resin-based sealers with regard to POP, while two suggested that bioceramic sealers reduced POP (Mekhdieva et al. 2021; Seron et al. 2023).

3.3 | Methodological Quality and Overall Confidence

An overview of the quality assessment for the reviews was provided in Figure 2. All the SRs adequately addressed the items 1 ('Did the research questions and inclusion criteria for the review include the components of PICO?'). One SR adequately addressed the Item 3 ('Did the review authors explain their selection of the study designs for inclusion in the review?') and Item 10 ('Did the review authors report on the sources of funding for the studies included in the review?'). The overall confidence in the findings of ten, two and one SR(s) was categorised as 'critically low', 'low' and 'high', respectively (Figure 2).

4 | Discussion

Considering the rapidly increasing number of published SRs, a crucial step in providing robust evidence for guiding clinical practice is the successful completion of an umbrella review including a methodological assessment of the SRs. This offers health decision-makers the most comprehensive scientific evidence in an understandable format. This umbrella review is the first in the literature to compare the influence of epoxy resin-based sealers and bioceramic sealers on POP following non-surgical RCT and retreatment.

From the current review, it is evident that there is no significant difference between the two sealers in combination with gutta percha in both primary RCT and retreatment. The epoxy resin-based sealer, AH plus, remains the predominantly used sealer and the current 'gold standard' (Pirani et al. 2019) as it is strongly advocated with a warm filling technique (Kandemir Demirci and Çalışkan 2016; Pirani et al. 2019). However, epoxy resin-based sealers have drawbacks in that they require a completely dry canal due to its hydrophobic nature and cytotoxicity during the initial set (Huang et al. 2002; Jung et al. 2018; Lee et al. 2017) as a result of leaching of the monomer, ether bisphenol-A-diglycidyl during setting (Lodiené et al. 2013;

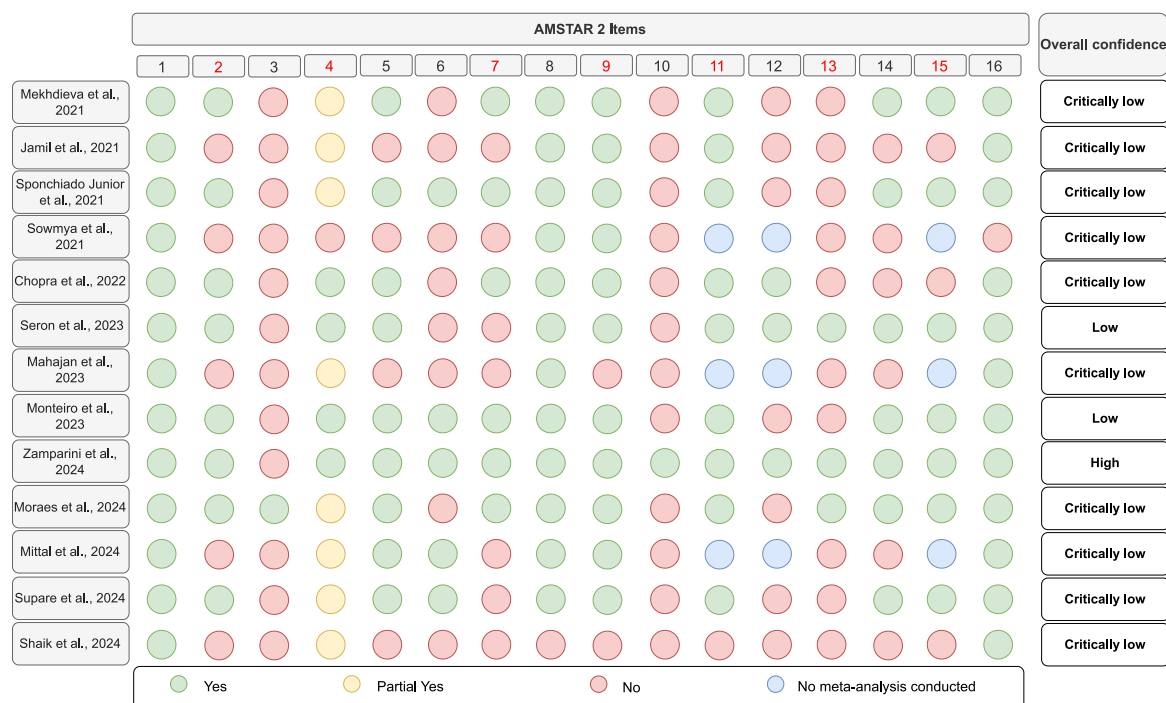


FIGURE 2 | Quality of the included systematic reviews. Critical domain of AMSTAR 2—*; (1) Did the research questions and inclusion criteria for the review include the components of PICO?; (2) Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?; (3) Did the review authors explain their selection of the study designs for inclusion in the review?; (4) Did the review authors use a comprehensive literature search strategy?; (5) Did the review authors perform study selection in duplicate?; (6) Did the review authors perform data extraction in duplicate?; (7) Did the review authors provide a list of excluded studies and justify the exclusions?; (8) Did the review authors describe the included studies in adequate detail?; (9) Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?; (10) Did the review authors report on the sources of funding for the studies included in the review?; (11) If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?; (12) If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?; (13) Did the review authors account for RoB in individual studies when interpreting/discussing the results of the review?; (14) Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?; (15) If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?; (16) Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?"

Zhang et al. 2010). Conversely, it has been shown that bioceramic sealers have a variable setting time, but better capacity to maintain cell viability and enhance cell migration compared with the epoxy resin-cement AH plus (Seo et al. 2019; López-García et al. 2020). Also, it is stated that bioceramics reduced the activation of nociceptors that are responsible for calcitonin gene-related peptide (CGRP) release that leads to inflammation and pain (Ruparel et al. 2014). Certain bioceramic sealers like MTA fillapex, and EndoSequence BC sealer exhibited reduced inflammatory markers like IL-6 interleukin-6 and TNF- α (Tumour Necrosis factor-alpha) resulting in reduced inflammation (Lee et al. 2019).

The apical extrusion of sealer during warm vertical compaction using epoxy resin-based sealer is higher than cold hydraulic condensation techniques using calcium silicate-based sealers (Kangseng et al. 2025). When both are used in a warm vertical compaction technique, epoxy resin-based sealers show significantly higher extrusion compared with bioceramic sealer (Hu et al. 2023); this was attributed to introducing a sealer-coated master cone rather than using

an injecting syringe (piston effect), iRoot SP's hydrophilicity and low radiopacity (Candeiro et al. 2012) but sealers in accordance with ISO standards should be detectable when extruded. Conversely, Fonseca et al. reported a high sealer extrusion with bioceramic sealers compared with resin sealers but the technique performed was a single cone technique in both groups (Fonseca et al. 2019). A systematic review reported that bioceramic sealers have also been shown to have reduced sealer extrusion compared with epoxy resin-based sealer (Seron et al. 2023). However, a limited amount of unintentionally extruded sealer is not significant enough to produce periapical inflammation (Drumond et al. 2021; Fonseca et al. 2019). This research highlights that both sealers may influence POP mechanisms after placement during RCT.

The initial version of AMSTAR was released in 2007, with 11 items (Shea et al. 2007), followed by AMSTAR 2, which was released in 2017, with 16 items (Shea et al. 2017). AMSTAR 2 is employed to evaluate the methodological quality of SRs and to detect significant deficiencies that may undermine confidence in the review's findings. When assessing the overall rating of a

SR, it is important to identify deficiencies in seven critical domains (Shea et al. 2017): (1) protocol registration, (2) adequacy of literature search, (3) justification for excluding individual studies, (4) the use of an adequate approach to assess the risk of bias in included studies, (5) the appropriateness of meta-analytical methods, (6) considering the risk of bias in result interpretation, and (7) the evaluation of the presence and potential impact of publication bias.

In this umbrella review, only one included SR adequately addressed Item 3. The selection of study designs for inclusion in SRs should be conducted with careful consideration rather than being subjective. It is imperative that authors provide a rationale for the incorporation of various study designs within SRs (Shea et al. 2017). Similarly, only one of the included reviews sufficiently addressed item 10, which pertains to the funding source. For example Lin et al. (2022) conducted an umbrella review with the objective of assessing the SRs on pulpotomy. They stated that none of the included SRs addressed the source of funding for each primary study. There have been a number of investigations that have demonstrated that studies that are sponsored by a commercial entity are more likely to provide conclusions that are favourable to the sponsor's product than studies that are funded independently (Lesser et al. 2007; Lexchin 2003). A Cochrane review concluded that sponsoring drug and device experiments by the manufacturing company yields more favourable outcomes compared to sponsorship from alternative sources (Lundh et al. 2017). Consequently, it is essential for authors of reviews to meticulously document the funding sources for each study incorporated in the review or to indicate that such information was not available in the study reports (Shea et al. 2017). Only two reviews sufficiently addressed the item about considering the risks of bias of individual studies when addressing the results of the review. The authors of SRs should highlight the influence of the risk of bias on the interpretation of the review's results, even if meta-analyses were not performed (Shea et al. 2017).

The review has the following parameters that can be presented as its strengths: (i) an a priori protocol was established and registered; (ii) a thorough and rigorous literature search was performed; (iii) two independent individuals conducted the literature search, data extraction and appraising the quality of reviews; (iv) a comprehensive methodological assessment of the existing SRs was carried out. The following parameters can be considered limitations of the review: (i) the majority of the SRs included in the current umbrella review include both primary RCTs and retreatment; (ii) the SR that was included in the current umbrella review comprised primary studies that covered teeth with a variety of diagnoses, such as pulp necrosis, irreversible pulpitis and apical periodontitis; (iii) the included SRs were published within a short period of time (2021–2024); (iv) although the literature search was conducted without language restrictions, all eligible systematic reviews identified were published in English; (v) several of the SRs included in the current UR are not published in journals with high impact-related metrics. However, SRs are generally not excluded in URs for this reason, as the objective of UR is to compile and present all available evidence on a specific subject.

In further, authors of SRs and meta-analyses should take into account the following criteria: (i) the protocol has to be registered in appropriate databases and it has to be reported in the review with the name and registration number; (ii) authors need to perform an exclusive search in grey literature databases, such as conference abstracts, and unpublished reports on personal websites; (iii) various study designs included must be justified clearly in the review; (iv) the review authors should consider the risk of bias of individual studies in their interpretation or discussion of the results; (v) the review authors should identify the confounding factors and perform an additional subgroup analysis; and (vi) the funding source of the included primary study needs to be reported as it might influence the results.

5 | Conclusion

This umbrella review demonstrated that bioceramic sealers exhibited comparable POP levels with epoxy resin-based sealers; however, the SRs contain numerous methodological deficiencies. Therefore, it is imperative that future SRs be conducted and reported in accordance with the recommendations of this umbrella review.

Author Contributions

All the authors made substantial contributions to the manuscript. All the authors have read and approved the final version of the manuscript.

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The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The authors have nothing to report.

References

- Álvarez-Vásquez, J. L., M. J. Erazo-Guijarro, G. S. Domínguez-Ordoñez, and É. M. Ortiz-Garay. 2024. "Epoxy Resin-Based Root Canal Sealers: An Integrative Literature Review." *Dental and Medical Problems* 61: 279–291.
- Aromataris, E., R. Fernandez, C. M. Godfrey, C. Holly, H. Khalil, and P. Tungpunkom. 2015. "Summarizing Systematic Reviews: Methodological Development, Conduct and Reporting of an Umbrella Review Approach." *International Journal of Evidence-Based Healthcare* 13: 132–140.
- Benetti, F., Í. O. De Azevedo Queiroz, P. H. C. D. Oliveira, et al. 2019. "Cytotoxicity and Biocompatibility of a New Bioceramic Endodontic Sealer Containing Calcium Hydroxide." *Brazilian Oral Research* 33: e042.
- Camilleri, J. 2020. "Classification of Hydraulic Cements Used in Dentistry." *Frontiers in Dental Medicine* 1: 9.

- Candeiro, G. T., F. C. Correia, M. A. Duarte, D. C. Ribeiro-Siqueira, and G. Gavini. 2012. "Evaluation of Radiopacity, pH, Release of Calcium Ions, and Flow of a Bioceramic Root Canal Sealer." *Journal of Endodontics* 38: 842–845.
- Cardinali, F., and J. Camilleri. 2023. "A Critical Review of the Material Properties Guiding the Clinician's Choice of Root Canal Sealers." *Clinical Oral Investigations* 27: 4147–4155.
- Carr, E., and A. MacInnes. 2022. "Do Resin-Based Sealers Increase Post-Operative Pain Following Root-Canal Treatment?" *Evidence-Based Dentistry* 23: 114–115.
- Chang, S.-W., S.-Y. Lee, S.-K. Kang, K.-Y. Kum, and E.-C. Kim. 2014. "In Vitro Biocompatibility, Inflammatory Response, and Osteogenic Potential of 4 Root Canal Sealers: Sealapex, Sankin Apatite Root Sealer, MTA Fillapex, and iRoot SP Root Canal Sealer." *Journal of Endodontics* 40: 1642–1648.
- Chopra, V., G. Davis, and A. Baysan. 2022. "Clinical and Radiographic Outcome of Non-Surgical Endodontic Treatment Using Calcium Silicate-Based Versus Resin-Based Sealers—A Systematic Review and Meta-Analysis of Clinical Studies." *Journal of Functional Biomaterials* 13: 38.
- Darcey, J., R. V. Roudsari, S. Jawad, C. Taylor, and M. Hunter. 2016. "Modern Endodontic Principles Part 5: Obturation." *Dental Update* 43: 114–129.
- Dong, X., and X. Xu. 2023. "Bioceramics in Endodontics: Updates and Future Perspectives." *Bioengineering* 10: 354.
- Drumond, J. P. S. C., W. Maeda, W. M. Nascimento, et al. 2021. "Comparison of Postobturation Pain Experience After Apical Extrusion of Calcium Silicate—And Resin-Based Root Canal Sealers." *Journal of Endodontics* 47: 1278–1284.
- Fonseca, B., M. S. Coelho, C. E. d. S. Bueno, C. E. Fontana, A. S. D. Martin, and D. G. P. Rocha. 2019. "Assessment of Extrusion and Postoperative Pain of a Bioceramic and Resin-Based Root Canal Sealer." *European Journal of Dentistry* 13: 343–348.
- Hu, J., Y. Zhu, S. Deng, Z. Wang, and F. He. 2023. "Outcome of Root Canal Treatment Using Warm Vertical Compaction With Bioceramic and Resin-Based Sealers: A Randomised Clinical Trial." *Australian Endodontic Journal* 49, no. Suppl 1: 170–178.
- Huang, T.-H., J.-J. Yang, H. Li, and C.-T. Kao. 2002. "The Biocompatibility Evaluation of Epoxy Resin-Based Root Canal Sealers In Vitro." *Biomaterials* 23: 77–83.
- Jamali, S., M. Darvish, N. Nasrabadi, and S. Jafarizadeh. 2021. "Evaluation of the Effect of the Intensity and Occurrence of Postoperative Pain of Resin-Based and Bioceramic Root Canal Sealers: A Systematic Review and Meta-Analysis of Randomized Controlled Trial Studies." *Pesquisa Brasileira Em Odontopediatria e Clínica Integrada* 21: e0219.
- Jung, S., S. Sielker, M. R. Hanisch, V. Libricht, E. Schäfer, and T. Dammaschke. 2018. "Cytotoxic Effects of Four Different Root Canal Sealers on Human Osteoblasts." *PLoS One* 13: e0194467.
- Kandemir Demirci, G., and M. K. Çalışkan. 2016. "A Prospective Randomized Comparative Study of Cold Lateral Condensation Versus Core/Gutta-Percha in Teeth With Periapical Lesions." *Journal of Endodontics* 42: 206–210.
- Kangseng, T., D. Banomyong, S. Osiri, and J. Jantararat. 2025. "Outcomes and Prognostic Factors of Endodontically Treated Teeth Filled With Calcium Silicate- or Epoxy Resin-Based Root Canal Sealers: A Retrospective Cohort Study." *International Endodontic Journal* 58: 84–96.
- Küçükaya Eren, S., E. Uzunoğlu-Özyürek, and S. Karahan. 2022. "Do Resin-Based Root Canal Sealers Cause More Postoperative Pain Than Other Sealers? A Systematic Review of Clinical Studies and Meta-Analysis." *Quintessence International* 53: 472–483.
- Lee, B.-N., J.-U. Hong, S.-M. Kim, et al. 2019. "Anti-Inflammatory and Osteogenic Effects of Calcium Silicate-Based Root Canal Sealers." *Journal of Endodontics* 45: 73–78.
- Lee, J. K., S. W. Kwak, J.-H. Ha, W. Lee, and H.-C. Kim. 2017. "Physicochemical Properties of Epoxy Resin-Based and Bioceramic-Based Root Canal Sealers." *Bioinorganic Chemistry and Applications* 2017: 1–8.
- Lesser, L. I., C. B. Ebbeling, M. Goozner, D. Wypij, and D. S. Ludwig. 2007. "Relationship Between Funding Source and Conclusion Among Nutrition-Related Scientific Articles." *PLoS Medicine* 4: e5.
- Lexchin, J. 2003. "Pharmaceutical Industry Sponsorship and Research Outcome and Quality: Systematic Review." *BMJ (Clinical Research Edition)* 326: 1167–1170.
- Lim, M., C. Jung, D.-H. Shin, Y. Cho, and M. Song. 2020. "Calcium Silicate-Based Root Canal Sealers: A Literature Review." *Restorative Dentistry & Endodontics* 45: e35.
- Lin, G. S. S., Y. Q. Yew, H. Y. Lee, et al. 2022. "Is Pulpotomy a Promising Modality in Treating Permanent Teeth? An Umbrella Review." *Odontology* 110: 393–409.
- Lodiené, G., H. M. Kopperud, D. Ørstavik, and E. M. Bruzell. 2013. "Detection of Leachables and Cytotoxicity After Exposure to Methacrylate- and Epoxy-Based Root Canal Sealers In Vitro." *European Journal of Oral Sciences* 121: 488–496.
- López-García, S., B. Myong-Hyun, A. Lozano, et al. 2020. "Cytocompatibility, Bioactivity Potential, and Ion Release of Three Premixed Calcium Silicate-Based Sealers." *Clinical Oral Investigations* 24: 1749–1759.
- Lundh, A., J. Lexchin, B. Mintzes, J. B. Schroll, and L. Bero. 2017. "Industry Sponsorship and Research Outcome." *Cochrane Database of Systematic Reviews* 2, no. 2: MR000033.
- Mahajan, D., D. Manocha, P. Patel, M. B. Saraiya, and K. Chaniyara. 2023. "A Systematic Review on Comparison of Periapical Healing and Post-Operative Pain Between Bioceramic and Epoxy Resin Based Sealers." *Journal of Pharmacy & Bioallied Sciences* 15: S862–S866.
- McGowan, J., M. Sampson, D. M. Salzwedel, E. Cogo, V. Foerster, and C. Lefebvre. 2016. "PRESS Peer Review of Electronic Search Strategies: 2015 Guideline Statement." *Journal of Clinical Epidemiology* 75: 40–46.
- Mekhdieva, E., M. Del Fabbro, M. Alovisei, et al. 2021. "Postoperative Pain Following Root Canal Filling With Bioceramic vs. Traditional Filling Techniques: A Systematic Review and Meta-Analysis of Randomized Controlled Trials." *Journal of Clinical Medicine* 10: 4509.
- Mittal, N., T. Thangamuthu, S. Gupta, S. Gupta, H. Aggarwal, and S. Kharat. 2024. "Comparative Evaluation of Resin-Based Sealers and Bioceramic Sealers for Postoperative Pain After Endodontic Treatment: A Systematic Review." *Dental and Medical Problems* 61: 293–300.
- Monteiro, C. M. C., A. C. R. Martins, A. Reis, and J. L. De Geus. 2023. "Effect of Endodontic Sealer on Postoperative Pain: A Network Meta-Analysis." *Restorative Dentistry & Endodontics* 48: e5.
- Montero, J., B. Lorenzo, R. Barrios, A. Albaladejo, J. A. Mirón Canelo, and A. López-Valverde. 2015. "Patient-Centered Outcomes of Root Canal Treatment: A Cohort Follow-Up Study." *Journal of Endodontics* 41: 1456–1461.
- Moraes, V. G., S. R. S. Meyfarth, G. A. Marañón-Vásquez, L. A. A. Antunes, and L. S. Antunes. 2024. "Influence of Root Canal Sealer Composition on Postoperative Pain After Endodontic Treatment of Permanent Teeth: A Systematic Review and Meta-Analyses." *Brazilian Dental Science* 27: e4060.
- Oliveira, P. S., K. N. B. Da Costa, C. N. Carvalho, and M. C. Ferreira. 2019. "Impact of Root Canal Preparation Performed by ProTaper Next or Reciproc on the Quality of Life of Patients: A Randomized Clinical Trial." *International Endodontic Journal* 52: 139–148.

- Page, M. J., J. E. McKenzie, P. M. Bossuyt, et al. 2021. "The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews." *BMJ (Clinical Research Edition)* 372: n71. <https://doi.org/10.1136/bmj.n71>.
- Pirani, C., F. Zamparini, O. A. Peters, et al. 2019. "The Fate of Root Canals Obturated With Thermafil: 10-Year Data for Patients Treated in a Master's Program." *Clinical Oral Investigations* 23: 3367–3377.
- Primus, C., J. L. Gutmann, F. R. Tay, and A. B. Fuks. 2022. "Calcium Silicate and Calcium Aluminate Cements for Dentistry Reviewed." *Journal of the American Ceramic Society* 105: 1841–1863.
- Ruparel, N. B., S. B. Ruparel, P. B. Chen, B. Ishikawa, and A. Diogenes. 2014. "Direct Effect of Endodontic Sealers on Trigeminal Neuronal Activity." *Journal of Endodontics* 40: 683–687.
- Sathorn, C., P. Parashos, and H. Messer. 2008. "The Prevalence of Postoperative Pain and Flare-Up in Single- and Multiple-Visit Endodontic Treatment: A Systematic Review." *International Endodontic Journal* 41: 91–99.
- Seo, D.-G., D. Lee, Y.-M. Kim, D. Song, and S.-Y. Kim. 2019. "Biocompatibility and Mineralization Activity of Three Calcium Silicate-Based Root Canal Sealers Compared to Conventional Resin-Based Sealer in Human Dental Pulp Stem Cells." *Materials* 12: 2482.
- Seron, M. A., G. P. Nunes, T. M. Ferrisse, et al. 2023. "Postoperative Pain After Root Canal Filling With Bioceramic Sealers: A Systematic Review and Meta-Analysis of Randomized Clinical Trials." *Odontology* 111: 793–812.
- Shaik, I., M. Kusuma, M. Elsayed, K. Veluru, A. Nabeel, and R. Sindhura. 2024. "Periapical Healing Outcome of Endodontic re-Treatment Using Calcium Silicates Versus Resin-Based Sealers: A Systematic Review." *Journal of Pharmacy & Bioallied Sciences* 16: S90–S92.
- Shea, B. J., J. M. Grimshaw, G. A. Wells, et al. 2007. "Development of AMSTAR: A Measurement Tool to Assess the Methodological Quality of Systematic Reviews." *BMC Medical Research Methodology* 7: 10.
- Shea, B. J., B. C. Reeves, G. Wells, et al. 2017. "AMSTAR 2: A Critical Appraisal Tool for Systematic Reviews That Include Randomised or Non-Randomised Studies of Healthcare Interventions, or Both." *BMJ (Clinical Research Edition)* 358: j4008.
- Sowmya, N. M. S. 2021. "Postoperative Pain Associated With Resin and Bioceramic Based Sealers: A Systematic Review." *International Journal of Dentistry and Oral Science* 8: 3613–3619.
- Sponchiado Junior, E. C., W. D. A. Vieira, A. G. C. Normando, et al. 2021. "Calcium Silicate-Based Sealers Do Not Reduce the Risk and Intensity of Postoperative Pain After Root Canal Treatment When Compared With Epoxy Resin-Based Sealers: A Systematic Review and Meta-Analysis." *European Journal of Dentistry* 15: 347–359.
- Supare, M., A. M. Pawar, K. Sawant, et al. 2024. "Effect of Bioceramic-Based and Resin-Based Sealers on Postoperative Discomfort Following Root Canal Therapy: A Systematic Review and Meta-Analysis." *PeerJ* 12: e18198.
- Zamparini, F., J. Lenzi, H. F. Duncan, A. Spinelli, M. G. Gandolfi, and C. Prati. 2024. "The Efficacy of Premixed Bioceramic Sealers Versus Standard Sealers on Root Canal Treatment Outcome, Extrusion Rate and Post-Obturation Pain: A Systematic Review and Meta-Analysis." *International Endodontic Journal* 57: 1021–1042.
- Zavattini, A., A. Knight, F. Foschi, and F. Mannocci. 2020. "Outcome of Root Canal Treatments Using a New Calcium Silicate Root Canal Sealer: A Non-Randomized Clinical Trial." *Journal of Clinical Medicine* 9: 782.
- Zhang, W., Z. Li, and B. Peng. 2010. "Ex Vivo Cytotoxicity of a New Calcium Silicate-Based Canal Filling Material." *International Endodontic Journal* 43: 769–774.

Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** Electronic Databases and Search Strategy. **Table S2:** Reasons for excluding the reviews after full text reading.