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Evidence-based selection of root canal sealers for different clinical indications: A review

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Abstract:
Root canal sealers are essential for sealing the interface between gutta-percha and canal walls, with bioceramic and epoxy-resin sealers being widely used. Therefore, it is of interest to integrate the professional guidelines, pooled clinical evidence and publication trends to develop an indication-based framework for sealer selection. Current evidence suggests comparable post-operative pain and short-to-medium-term healing between bioceramic and epoxy-resin sealers, with differences in extrusion and retreatability. Sealer selection should therefore be based on clinical indication, canal characteristics, periapical status and the anticipated need for retreatment rather than routine preference. This review advances knowledge by providing a structured, case-oriented decision framework that balances the biological advantages of bioceramic sealers with their retreatability limitations.

Keywords: Root canal sealer, bioceramic, calcium silicate, epoxy resin, clinical practice guideline, endodontics, evidence-based dentistry

Background:
Gutta-percha performs the visible work of obturation, but on its own it seals nothing: it has no adhesive grip and no hermetic capacity of its own **[1]**. The sealer packed around it is what actually closes the space between the filling material and the dentinal wall and the chemistry available for that job has changed more in the last fifteen years than in the previous fifty **[1]**. Zinc oxide-eugenol (ZOE) dominated for much of the twentieth century, gave ground to calcium-hydroxide and glass ionomer formulations and then to epoxy-resin sealers, which became the de facto standard from the 1990s onward **[1]**. The newest entrant, premixed hydrophilic calcium-silicate sealers, arrived after roughly 2010 and has since attracted a strikingly disproportionate share of new comparative research **[2]**. Guidance has not kept pace with the chemistry. Manufacturers make sealer-specific claims, single-centre trials produce sealer-specific headlines and narrative reviews often repeat both without much scrutiny. What a working clinician actually needs is something rooted in professional-body positions rather than marketing copy, weighted by pooled trial evidence rather than one favourable study and converted into a tool usable at the chair. That is the gap this review tries to close **[3].** Two professional bodies currently anchor the evidence base **[4, 5]**. The European Society of Endodontology's 2023 guideline is its first to reach the top tier of the AWMF classification and on filling materials specifically it is deliberately permissive: obturation with gutta-percha and sealer is acceptable with epoxy-resin, zinc oxide–eugenol, or calcium-silicate sealers, whichever compaction technique is used **[4]**. The American Association of Endodontists' clinical resource on bioceramic materials frames the newer chemistry a moisture-driven setting reaction, a hydroxyapatite-forming surface and a slight expansion on set as a set of trade-offs to be weighed against case-specific handling demands rather than a reason to abandon resin sealers altogether **[5].** Individual trials and cohort studies sit beneath these pooled analyses as illustrative examples rather than the product of an independent, exhaustive search conducted specifically for this review; this is a structured synthesis of already-published work rather than a new head to head trial or a fresh meta-analysis and it should be read with that scope in mind **[6].** A third, complementary layer of evidence steps back from clinical outcomes altogether to look at the shape of the literature itself **[7]**. A citation-mapping exercise on calcium-silicate materials shows a sharp, sustained climb in output between the mid-1990s and 2020 and a related analysis of the most cited articles on bioceramic sealers specifically finds that this literature now forms its own tightly connected citation cluster rather than sitting as a subset of general sealer research **[7].** Tracking how a research area grows does not, by itself, prove that one sealer performs better, but it does show where the evidence is thick and where it is still thin useful context for a case based guide **[7].** This review therefore brings professional body guidance, pooled trial evidence and publication-trend data together into one graded, indication based framework for sealer selection, built around four evidence tables and a chairside decision guide **[8]**, illustrated through five recent comparative studies published between 2023 and 2026 that show where the evidence currently converges and where it still diverges, before closing with the limitations of a narrative synthesis of this kind and a short, practical conclusion. Therefore, it is of interest to evaluate the current professional body guidance and pooled trial evidence can be translated into a practical, indication-based framework for choosing between epoxy-resin and bioceramic sealers at the chair.

Sealer chemistry and classification:
Four broad chemistries currently account for the sealers used in everyday practice and their setting reactions largely explain their distinguishing clinical behaviour. Zinc oxide-eugenol sealers set through an acid base chelation reaction and remain a legacy comparator, valued historically for their antibacterial eugenol content but limited by progressive resorption and solubility over time. Epoxy resin sealers, typified by AH plus, set through epoxide–amine polyaddition and have served as the reference standard for over two decades because of their low solubility, dimensional stability and strong dentinal adhesion, at the cost of technique-sensitivity to canal dryness and slight polymerization shrinkage. Premixed calcium-silicate (bioceramic) sealers set through a hydration reaction that is triggered by residual canal moisture rather than hindered by it and are bioactive, biocompatible and low-shrinkage or slightly expansile, though they carry a premium cost and documented retreatability trade-

offs. Bioactive-glass sealers are the newest and least-studied class, with early trials suggesting a favourable short-term pain profile but still-limited long-term clinical data **[9]**. A recent three arm trial found lower short-term pain and less analgesic use with a bioactive-glass sealer than with an epoxy-resin comparator **[17]**. The chemistry and clinical characteristics of the major root canal sealer classes, including zinc oxide–eugenol, epoxy resin, calcium hydroxide, calcium silicate (bioceramic) and bioactive glass, are summarized in **Table 1.** The comparative clinical evidence for bioceramic and epoxy-resin sealers, including postoperative pain, apical extrusion, sealing ability, retreatability and biocompatibility, is presented in **Table 2**, highlighting the reported outcomes and corresponding levels of evidence certainty.

Table 1: Sealer classes at a glance

Sealer class	Chemistry / setting reaction	Distinguishing clinical properties
Zinc oxide–eugenol (ZOE)	Acid–base chelation reaction	Long historical track record; antibacterial eugenol; progressive resorption/solubility over time; largely a legacy comparator today
Epoxy resin (e.g., AH Plus)	Epoxide–amine polyaddition	Low solubility, dimensional stability, strong dentinal adhesion; slight polymerisation shrinkage; technique-sensitive to canal dryness; reference standard for over 20 years
Calcium hydroxide–based	Chelation, high initial pH	Antibacterial via alkalinity; weaker long-term seal; largely superseded
Premixed calcium silicate ("bioceramic")	Hydration reaction, moisture-driven	Bioactive, biocompatible, hydrophilic (sets in residual moisture); low shrinkage/slight expansion; documented retreatability trade-offs; premium cost
Bioactive glass–based	Ion-exchange bioactivity, silica network dissolution	Emerging class; early trials suggest a favourable short-term pain profile; long-term clinical data still limited

Table 2: Pooled evidence summary by clinical outcome

Outcome	Pooled finding	Certainty	Key evidence
Postoperative pain	Broadly equivalent at 24 and 48 hours between bioceramic and epoxy-resin sealers	Low–moderate	**[8, 9]**
Apical extrusion	Less, or less clinically consequential, extrusion with bioceramic sealers	Moderate	**[5]**
Sealing ability (microleakage)	No significant difference; favourable but not uniformly superior for bioceramic sealers	Moderate	**[6]**
Retreatability	Resin sealers clear faster but leave more residue; bioceramic sealers slower, technique-dependent	Moderate	**[5, 7]**
Biocompatibility	Comparable once set; transient toxicity in freshly mixed material across most families	Moderate	**[11]**

Table 3: Evidence gaps and what they mean for confidence

Gap	What it means for confidence
Short follow-up in most bioceramic trials (≤6–12 months)	Long-term (≥4-year) survival recommendations stay provisional rather than settled
Pain measured differently across trials (scale format, time points)	Limits precision of combined pain estimates; certainty runs low to moderate
Uneven trial registration and conflict-of-interest disclosure, especially pre-2018	Selective reporting cannot be fully ruled out for older trials feeding some pooled analyses
Retreatability data concentrated in laboratory/simulated-groove models	How well these findings hold in real patients is inferred, not yet directly shown, for several bioceramic brands
Sparse head-to-head data for bioactive-glass sealers	This class is discussed qualitatively but not built into the chairside decision guide

Table 4: Chairside decision guide by clinical indication

Clinical indication	First-line sealer	Strength of backing
Routine vital pulp, straightforward anatomy	Epoxy resin or bioceramic	Strong — equivalence
Necrotic pulp, apical periodontitis	Bioceramic preferred	Moderate
Large periapical lesion (≥5–10 mm)	Bioceramic preferred, technique-dependent	Moderate—still developing
Retreatment of a resin/ZOE-filled canal	Either class	Strong
Retreatment of a bioceramic-filled canal	Plan extended ultrasonic/laser-assisted removal	Moderate
Immature apex / regenerative procedure	Calcium silicate (MTA-type) + bioceramic sealer	Strong
Single-visit, residual canal moisture	Hydrophilic bioceramic sealer	Moderate
Documented resin/epoxy-amine allergy	Bioceramic (non-resin)	Strong — mechanistic
Cost-constrained setting	Epoxy resin as default; bioceramic for strong indications above	Strong — practical

Professional body guidance:

The ESE's 2023 guideline is deliberately permissive on filling materials: cold lateral compaction, warm vertical compaction, a carrier-based technique, or single cones are all acceptable with epoxy-resin, zinc oxide eugenol, or calcium-silicate sealers **[10]**. That is a meaningful signal for the guide built here the highest tier of endodontic guidance currently available does not crown a winner and leaves the choice to case-level judgement informed by the comparative evidence set out below. The ESE's earlier position statement on restoring root-filled teeth follows the same logic, treating sealer and filling-material choice as one piece of a broader, case-specific restorative plan rather than a fixed rule and states plainly that guidance will be revised as new evidence accumulates. The AAE's clinical resource on bioceramic materials lays out the underlying chemistry in practical terms: nanoparticle formulations engineered for adequate flow, a moisture-driven setting reaction that leaves behind a hydroxyapatite-forming surface and a slight expansion on set that contrasts with the shrinkage typical of resin sealers and the slow dissolution typical of zinc oxide–eugenol systems **[11]**. Rather than declaring a favorite, the AAE frames these as trade-offs to be weighed against case-specific handling demands, such as how dry the canal is or whether a single cone or multiple cones will be used a framing that dovetails with the ESE's stance and with the case-based guide later in this review.

Evidence on clinical outcomes:

Postoperative pain is the most heavily studied outcome. Recent pooled efforts combining dozens of individual randomised trials point to roughly equal pain at 24 and 48 hours between bioceramic and epoxy-resin families, with certainty running low to moderate and much of the scatter traceable to differences in pain-scale format, follow-up timing and pulp diagnosis **[12]**. Not every individual trial agrees with this equivalence story and several three-arm trials have found statistically lower short-term pain with calcium-silicate materials, but that signal does not repeat cleanly across the wider pooled evidence. On apical extrusion and healing, pooled analyses generally point toward less, or less clinically consequential, extrusion with bioceramic materials, without establishing a clear win on overall treatment success. A matched retrospective cohort that controlled for retreatment status, lesion size and completeness of canal filling found comparable clinical outcomes between a calcium-silicate sealer placed with cold hydraulic condensation and an epoxy-resin sealer placed with warm vertical compaction, a useful reminder that obturation technique and case selection carry much of the outcome alongside sealer chemistry. On sealing ability specifically, a meta-analysis of 24 *in vitro* and *ex vivo* studies found no significant difference in microleakage between the two families, with favourable but not uniformly superior results for bioceramic sealers. Retreatability is where the two leading families part ways most consistently: resin-based sealers generally clear faster from simulated canal irregularities but more often leave measurable residue behind, while bioceramic sealers take longer and typically need ultrasonic or laser assistance, though in several comparative setups they can be cleared more completely from grooves and connecting spaces. On biocompatibility, a wide-ranging review of laboratory cell-toxicity data found that toxicity tracks composition and test conditions rather than splitting neatly along resin versus bioceramic lines, with freshly mixed material from most families showing transient toxicity that faded substantially once set.

Evidence gaps and confidence:

No evidence base this young is complete and it is worth being explicit about where it runs thin before turning it into recommendations. Follow-up in most bioceramic trials is short, pain is measured inconsistently across studies, trial registration and conflict-of-interest disclosure are uneven for older trials, retreatability data are concentrated in laboratory models and head-to-head data for bioactive-glass sealers remain sparse. **Table 3** sets out what each of these gaps means for how firmly a recommendation can be made.

A case-based guide to sealer selection:

Pulling the professional-body guidance, the pooled trial evidence and the evidence gaps together, the most defensible approach is to choose by indication rather than by habit, in step with the ESE's top-tier guideline explicitly declining to mandate one sealer family **[14].** Each recommendation in **Table 4** carries a rough sense of how strong its backing is: "strong" means professional-body guidance and pooled trial evidence point the same way; "moderate" means the trial evidence is consistent but not unanimous; "still developing" flags an actively researched area. This is a clinical translation of the evidence above, not a formal statistical rating and it is intended to be used alongside, not instead of, individual clinical judgement. Recent work proposing a structured multi-criteria scoring index for sealers points toward a more formalised version of this kind of comparison in the future **[16]**.

Comparison with previous studies:

The comparative evidence published between 2023 and 2026 broadly supports a picture of clinical equivalence on the outcome measured most often, tempered by real trade-offs on extrusion, sealing and retreatability. Rekha *et al.* (2023) **[11]** pooled 24 *in vitro* and *ex vivo* studies and found no significant difference in microleakage-based sealing ability between bioceramic and epoxy-resin sealers, with the two families performing comparably across most obturation techniques and file systems. Zamparini *et al.* (2024) **[12]**, in a systematic review and meta-analysis of root canal treatment outcome, extrusion rate and post-obturation pain, reported low-to-moderate certainty evidence that premixed bioceramic sealers reduce apical extrusion relative to standard sealers, without establishing a clear advantage in overall treatment success. Kangseng *et al.* (2025) **[13]**, in a retrospective cohort study that controlled for retreatment status and lesion size, found comparable clinical outcomes between a calcium-silicate sealer placed with cold hydraulic condensation and an epoxy-resin sealer placed with warm vertical compaction, underscoring that obturation technique and case selection contribute as much to outcome as sealer chemistry. More recently, two independent umbrella reviews reached converging conclusions on postoperative pain: Dahikar *et al.* (2026) **[14]** synthesized Randomised trials nested within existing systematic reviews and found no clinically meaningful difference in pain between bioceramic and epoxy-resin sealers at 24 and 48 hours, while Govindaraju *et al.* (2026) **[15]**, analysing primary treatment and retreatment cases separately, described the underlying evidence as low-to-moderate in certainty and shaped heavily by pulp diagnosis and brand. Taken together, these five studies indicate that bioceramic and epoxy-resin sealers now sit on comparable evidential footing for pain and short-to-medium-term healing, that bioceramic materials may carry a modest advantage in extrusion control and that retreatability and long-term (four-year-plus) outcome data remain the areas where confidence is lowest. Therefore, sealer selection should continue to be individualised according to canal status, lesion size, moisture control, retreatment likelihood and patient factors such as resin allergy, rather than defaulting to either family out of habit.

Conclusion:

No single root canal sealer is optimal for every clinical situation, supporting an indication-based approach guided by clinical evidence and professional recommendations. Bioceramic sealers offer potential advantages in extrusion control and moisture tolerance, whereas epoxy-resin sealers remain cost-effective alternatives for routine cases. Sealer selection should balance

clinical indications, retreatability and long-term prognosis as stronger long-term evidence emerges.

Limitations:

This is a narrative review, not a systematic one and it draws together already published pooled analyses, umbrella reviews and publication-trend data rather than conducting an independent search and quality appraisal of every underlying trial; the grading used in the case-based guide should therefore be read as a structured clinical translation of currently published evidence, not a freshly and independently conducted evidence rating. Most bioceramic-sealer trials follow patients for six to twelve months at most, so recommendations regarding long-term (four-year-plus) survival and retreatability remain provisional and pain outcomes are measured with inconsistent scales and follow-up windows across trials, which limits the precision of pooled estimates. Retreatability data are concentrated in laboratory and simulated-groove models, so how well these findings generalise to real patients is inferred rather than directly showed for several bioceramic brands and head-to-head data for bioactive-glass sealers remain too sparse to build into a formal decision framework. Only English language sources were consulted, which may have excluded relevant regional guidance or trial data.

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