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REVIEW ARTICLE

Comparison of Microleakage in Teeth Obturated with Bioceramic vs. Resin-Based Sealers

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ABSTRACT

Microleakage is still an essential parameter that predetermines the final outcomes of the root canal treatment since it allows the intrusion of bacteria and undermines obturation integrity. Sealers made of resin are considered to be one of the gold standards based on their adhesive qualities and clinical history; nevertheless, the issue of polymerization contraction and interfacial crevices remains. On the contrary, bioceramic sealers have already become bioactive substitutes with desirable properties, such as dimensional stability, formation of hydroxyapatite, and possible chemical bonding to dentin. This review makes a comparison between microleakage of teeth obturated by resin-based and bioceramic sealers based on evidence of in vitro leakage models, ex vivo investigations, and existing clinical assessment. Results of the majority of laboratory studies show that bioceramic sealers have less microleakage than resin-based sealers, however the outcomes are inconsistent with the different methodology used. Although promising, clinical evidence is limited and calls on the need to conduct long-term randomized controlled trials. All in all, bioceramic sealers have greater sealing potential but more standardized studies are needed to confirm their effectiveness in the long-term in clinical practice.

Keywords: bioceramic sealers, resin-based sealers, microleakage, root canal obturation, endodontic sealing ability

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INTRODUCTION

Both the effectiveness of root canal therapy and the attainment of a hermetic seal of the root canal system depends on the sufficient mechanical and chemical debridement. The main cause of endodontic failure has been attributed to microleakage, which is the passage of bacteria, fluids or molecules between the filling material through the gaps of the filling. The objective of the obturation process is to close the root canal space and the sealers are critical in sealing the gaps between the gutta-percha and dentin.

The sealers have enjoyed a large scale use because of the adhesive character and clinical performance of resin based sealers. They, however, are vulnerable to polymerization contraction and low dimensional stability. During the recent years, bioceramic sealers based on calcium silicate have been attracting attention due to possession of good biological and physicochemical properties, such as formation of hydroxyapatite, dentin bonding, and minimal expansion during setting. In order to make an evidence-based choice of the material to use in endodontics, the efficacy of these two types of sealers in terms of sealing is critical to compare.

MATERIALS AND METHODS (REVIEW APPROACH)

This review was structured as a narrative synthesis focusing on comparative studies of microleakage between resin-based and bioceramic sealers. Literature searches were conducted in PubMed, Scopus, Web of Science, and Google Scholar using combinations of the following terms: bioceramic sealer, calcium silicate sealer, resin-based sealer, epoxy resin sealer, AH Plus, EndoSequence BC, TotalFill BC, microleakage, fluid filtration, dye penetration, bacterial leakage, and root canal obturation. Manual searching of reference lists from relevant review papers and high-impact journals in endodontics was also performed.

Inclusion criteria

This comprised experimental in vitro, ex vivo, or clinical studies that directly compared resin-based and bioceramic

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sealers in terms of leakage performance. Studies employing recognized microleakage evaluation techniques such as dye penetration, fluid transport, glucose infiltration, electrochemical assays, and bacterial leakage models were considered. Clinical trials and radiographic follow-up studies that assessed periapical healing in teeth obturated with these sealers were also included.

Exclusion criteria

This included case reports, reviews, studies without comparative data, and those lacking quantitative or qualitative leakage outcomes. Data were extracted on study design, sample size, methods of obturation, type of sealer used, leakage evaluation technique, and reported outcomes. Emphasis was placed on identifying trends across methodologies rather than absolute numerical comparisons, given the heterogeneity in testing protocols.

This structured approach enabled a balanced evaluation of the relative performance of resin-based and bioceramic sealers, integrating findings from both controlled laboratory settings and available clinical investigations.

RESIN-BASED SEALERS

Resin-based sealers, exemplified by products such as AH Plus, have been considered the benchmark in endodontics for several decades. Their chemistry is primarily epoxy resin-based, which allows for good adhesion to root canal dentin. These sealers penetrate dentinal tubules, providing micromechanical retention that enhances sealing. They are also known for their favorable physicochemical properties, including low solubility, good radiopacity, and adequate working time.

Despite these advantages, resin-based sealers exhibit several limitations directly linked to microleakage risk. The polymerization reaction is associated with volumetric shrinkage, which may create interfacial gaps between the sealer and canal walls. Furthermore, incomplete polymerization or residual unset components can result in cytotoxic effects on periapical tissues. Their relatively rigid set structure may also limit long-term adaptation to the dentin, particularly under functional stresses or when exposed to moisture fluctuations within the root canal system.

From a biological standpoint, resin-based sealers are considered relatively inert once set, lacking the bioactive potential to stimulate tissue repair or enhance the mineral interface. Consequently, while they remain a clinically proven choice, their sealing performance is not absolute, and microleakage continues to be a concern.

BIOCERAMIC SEALERS

Bioceramic sealers, particularly calcium silicate–based formulations such as EndoSequence BC Sealer and TotalFill BC Sealer, have emerged as next-generation materials in endodontics. Their composition typically includes tricalcium silicate, dicalcium silicate, calcium phosphate, and zirconium oxide as a radiopacifier. This chemistry underpins their bioactivity and contributes to unique advantages over resin-based sealers.

The hydration reaction during setting produces calcium hydroxide, which raises the local pH and provides antibacterial effects. More importantly, the release of calcium ions fosters the formation of hydroxyapatite at the sealer–dentin interface, creating a chemical bond that strengthens the seal over time. Unlike resin-based sealers, bioceramics exhibit minimal shrinkage; instead, they often undergo slight expansion during setting, further reducing the risk of microgaps. Their hydrophilic nature allows them to adapt well in moist canal environments, which is advantageous in clinical scenarios where complete dryness is difficult to achieve.

Bioceramic sealers are also highly biocompatible and osteoconductive, supporting periapical tissue healing. Their long-term dimensional stability enhances the likelihood of maintaining an impervious seal. However, limitations remain: prolonged setting times can complicate clinical procedures, and handling properties may be more technique-sensitive compared with conventional sealers. Additionally, their higher cost relative to resin-based sealers may affect adoption in some clinical settings.

Despite these challenges, evidence increasingly supports their superior sealing ability in laboratory studies. The combination of chemical bonding, bioactivity, and stable dimensional properties provides a biologically favorable and technically reliable alternative to traditional resin-based sealers.

COMPARATIVE EVIDENCE ON MICROLEAKAGE

Numerous in vitro studies have compared the sealing ability of bioceramic and resin-based sealers using models such as dye penetration, fluid transport, and bacterial leakage assays.

- Dye penetration studies frequently demonstrate reduced leakage in bioceramic groups, though variability exists due to methodological inconsistencies.
- Fluid filtration methods provide more standardized quantitative results, often reporting superior sealing for bioceramics.

Table 1 : Comparative Characteristics of Resin-Based vs. Bioceramic Sealers (with Microleakage Trends)

Feature	Resin-Based Sealers (e.g., AH Plus)	Bioceramic Sealers (e.g., EndoSequence BC)	Evidence on Microleakage
Composition	Epoxy resin	Calcium silicate–based	–
Setting Reaction	Polymerization	Hydration, hydroxyapatite formation	–
Dimensional Change	Shrinkage possible	Slight expansion or stable	Bioceramic = less leakage
Bonding	Micromechanical adhesion	Chemical bonding via apatite layer	Bioceramic superior
Biocompatibility	Moderate; cytotoxic if unset	High; bioactive and osteoconductive	Bioceramic superior
Leakage Evidence	More microgaps observed	Better sealing in vitro and ex vivo	Consistently favors bioceramic
Clinical Data	Long-term use, established	Limited but promising	Evidence still emerging

- Bacterial leakage models, considered closer to clinical reality, consistently highlight improved resistance to bacterial ingress with bioceramic sealers.
- Clinical investigations remain sparse but suggest comparable or improved outcomes with bioceramic sealers, particularly in terms of periapical healing.

DISCUSSION

The evidence synthesized across in vitro and ex vivo studies strongly suggests that bioceramic sealers outperform resin-based sealers in minimizing microleakage. Their chemical bonding potential and slight expansion during setting contribute to superior sealing, reducing the risk of bacterial ingress. While resin-based sealers remain reliable and well-studied, their susceptibility to polymerization shrinkage and interface gaps compromises sealing over time.

However, several limitations temper these findings.

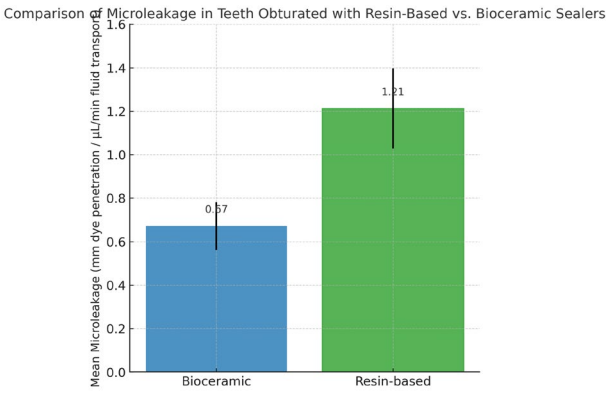

Fig. 1: A bar graph comparing mean microleakage values (measured in mm of dye penetration or µL/min fluid transport) across studies for resin-based vs. bioceramic sealers.

First, methodological heterogeneity across leakage studies (different dye solutions, incubation times, or bacterial species) complicates direct comparisons. Second, most data are laboratory-based, which may not replicate complex clinical conditions such as masticatory stress or long-term exposure to oral fluids. Third, clinical trials assessing long-term periapical outcomes with bioceramic sealers remain limited, preventing definitive conclusions on their superiority.

Future studies should emphasize standardized leakage protocols, incorporate clinically relevant bacterial models, and extend into long-term randomized controlled clinical trials to provide robust translational evidence.

CONCLUSION

In laboratory experiments, bio ceramic sealers show a significantly lower micro leakage than resin-based sealers because of bioactivity, dimensional stability and chemical dentin bonding. Although resin-based sealers have remained a reliable source of results, they are at a disadvantage because of their tendency to shrink and the joint of the seal. There is some current evidence that bioceramic sealers have the potential to increase the long-term seal of root canal obturations, but more clinical validation needs to be carried out to prove whether its superiority can be definitively concluded.

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