REVIEW ARTICLE

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Effect of Different Sealers on Adhesion and Sealability of Gutta-Percha in Root Canals

Mehak Trehan

BDS,India

ABSTRACT

Although gutta-percha has long been proven as a gold standard obturation material, its non-adhesive nature to the dentin requires the use of sealers to seal the voids, conform to canal anomalies, and increase the long-term sealability. The ability of adhesion to both dentin and gutta-percha, and the ability to resist microleakage with time, are the key characteristics of performance of a root canal sealer. Many types of sealers have been developed with varying degrees of ease such as the conventional zinc oxide-eugenol mixtures to resin based sealers and, most recently, calcium silicate-based bioceramics. The physicochemical and biological properties are different in each of the classes and consequently affect adhesion and sealing behavior. Comparative research has indicated that resin based sealers are better in bonding dentin by micromechanical interlocking, but bio ceramic sealers are better in terms of chemical bonding, bioactivity and long term dimensional stability. Conversely, zinc oxide-eugenol sealers offer lower adhesion and they have the tendency to dissolve casting doubt on their effectiveness in the long term. This review critically analyses the existing evidence touching on the adhesive and sealing properties of various sealers with recent developments and clinical implications. A particular focus is made on laboratory models which are applied to test adhesion and microleakage and their applicability to clinical performance. There is collective evidence that there is a trend towards the use of calcium silicate-based sealers due to their better sealing and biological properties, even though additional clinical trials would be justified to be able to prove their effectiveness in the long term.

Keywords: root canal sealers, gutta-percha, adhesion, sealability, resin-based sealer, bioceramic sealer, microleakage

1. INTRODUCTION

Root canal therapy is ultimately to ensure the prevention of reinfection of the root canal system through comprehensive cleaning, shaping and obturation. Obturation does not only fill the prepared canal space, it also seals it so that no microorganisms and their by-products can enter inside it. Although the use of gutta-percha as the core material has been used over the decades, it has a weakness in that it cannot chemically bond to the dentin. This requires application of sealers, which is at a point of critical contact between gutta-percha and dentin and which seal microscopic discontinuities and adapt to canal anomalies.

The development of sealers has changed over the years with the desire to enhance adhesion, sealability and biocompatibility. Historically, sealers made of zinc oxide-eugenol were the most commonly used in clinical practice, but the solubility and poor bonding potential led to the creation of resin-based ones. Calcium silicate-based sealers (which are often referred to as bioceramic sealers) have become more popular recently because of their bioactivity, dimensional stability and possible chemical bonding. The knowledge of the adhesive and sealing properties of such materials is important to predict clinical performance and selections of sealers.

This review examines the biomechanical etiology of adhesion and sealability, compares the various types of sealers and summarizes existing evidence, providing information on their clinical implications.The hermetic, three-dimensional seal of the root canal system is the key towards successful endodontics.

1.1. Types of Root Canal Sealers

1.1.1. Zinc Oxide–Eugenol Sealers

Zinc oxide–eugenol (ZOE) sealers represent the earliest

Corresponding author
Mehak Trehan
Email : BDS,India

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widely used formulations. They are set via an acid–base reaction and provide antibacterial effects due to eugenol release. However, they exhibit limited adhesion to dentin, poor bonding to gutta-percha, and are prone to solubility over time. Despite these limitations, their long history of use has made them a benchmark for comparing newer materials.

1.1.2. 2.2 Resin-Based Sealers

Epoxy resin sealers, such as AH Plus, are considered the gold standard in many practices due to their superior adhesion to dentin, low solubility, and favorable handling properties. They bond micromechanically to dentin through penetration into the collagen network and dentinal tubules, creating a strong interface. Nevertheless, shrinkage during polymerization and difficulties in retreatment remain concerns.

1.1.3. 2.3 Calcium Silicate–Based Sealers (Bioceramic Sealers)

Bioceramic sealers have emerged as a major innovation, offering bioactivity, high pH, and the ability to form hydroxyapatite at the sealer–dentin interface. These properties enhance chemical bonding, provide dimensional stability, and promote healing. They also exhibit excellent flowability, allowing penetration into dentinal tubules. A limitation, however, is their difficulty of removal during retreatment.

1.1.4. 2.4 Other Sealers

Glass ionomer–based sealers provide fluoride release and chemical adhesion but suffer from poor handling and limited use. Silicone-based sealers, such as polydimethylsiloxane formulations, exhibit biocompatibility but limited adhesion, making them less commonly used.

2. 3. MECHANISMS OF ADHESION AND SEALABILITY

Adhesion of sealers is influenced by both chemical and physical factors.

- Micromechanical interlocking occurs when sealers penetrate dentinal tubules, creating a hybrid layer. Resin-based sealers excel in this mechanism.
- Chemical bonding is achieved when sealers react with dentin, as observed with calcium silicate–based materials forming hydroxyapatite at the interface.
- Sealer–gutta-percha interaction remains a challenge, as most sealers lack true chemical affinity for gutta-percha. Innovations in surface treatments and coated cones aim to address this.

Sealability depends not only on adhesion but also on dimensional stability, setting expansion/shrinkage, and resistance to dissolution. Bioceramic sealers demonstrate slight expansion upon setting, enhancing seal integrity, whereas ZOE sealers shrink and dissolve over time.

3. 4. COMPARATIVE EVALUATION OF SEALERS

The performance of root canal sealers is often assessed using laboratory models that evaluate adhesion, microleakage, and durability. These models provide valuable insights into how different formulations interact with dentin and gutta-percha.

3.1. 4.1 Methods of Evaluation

3.1.1. Push-Out Bond Strength Tests

These tests measure the force required to dislodge the sealer from the dentinal wall. Resin-based sealers consistently demonstrate higher push-out bond strengths compared to zinc oxide–eugenol (ZOE) sealers, while bioceramic sealers achieve comparable or superior values due to their chemical interaction with dentin.

3.1.2. Microleakage Models

Dye penetration, bacterial leakage, and fluid filtration techniques are commonly employed to measure the sealability of root canal fillings. Resin-based sealers typically show reduced leakage compared with ZOE, but bioceramic sealers outperform both in long-term studies because of their dimensional stability and expansion upon setting.

3.1.3. Microscopic Analysis

Scanning electron microscopy (SEM) and confocal laser scanning microscopy provide direct visualization of dentinal tubule penetration and interface integrity. Resin-based sealers penetrate tubules extensively due to low viscosity, while bioceramic sealers demonstrate mineral deposition along tubule walls, forming a stable interfacial layer.

3.2. 4.2 Performance of Zinc Oxide–Eugenol Sealers

ZOE sealers exhibit limited adhesion, relying solely on mechanical interlocking. They are prone to solubility, resulting in marginal gaps and long-term leakage. Despite these limitations, they retain antibacterial effects from eugenol release, which may offer temporary benefits.

3.3. 4.3 Performance of Resin-Based Sealers

Resin sealers such as AH Plus remain the benchmark in clinical use. They provide high bond strengths due

Table 1 : Comparative Properties of Major Root Canal Sealers

Sealer Type	Adhesion to Dentin	Adhesion to Gutta-Percha	Sealability	Advantages	Limitations
Zinc oxide–eugenol	Weak, mechanical only	Poor	Limited; prone to leakage	Long history of use, antibacterial	Soluble, brittle, poor adhesion
Resin-based (e.g., AH Plus)	Strong micromechanical	Moderate	Good, but shrinkage risk	Low solubility, high bond strength	Polymerization shrinkage, retreatment difficulty
Bioceramic (calcium silicate)	Chemical + micromechanical	Moderate	Excellent; dimensional stability	Bioactivity, hydroxyapatite formation, expansion on setting	Difficult retreatment, cost
Glass ionomer	Chemical	Weak	Fair	Fluoride release, chemical adhesion	Handling difficulties, limited adoption
Silicone-based	Weak	Poor	Fair	Biocompatibility, flexibility	Limited adhesion, low popularity

to micromechanical retention within tubules and the creation of a hybrid layer. Their low solubility enhances long-term sealing. However, polymerization shrinkage can compromise adaptation, and retreatment is often challenging due to their strong dentin bonding.

3.4. 4.4 Performance of Bioceramic Sealers

Calcium silicate–based sealers represent a newer class with promising results. They bond chemically by forming hydroxyapatite, in addition to micromechanical penetration. Their slight setting expansion improves adaptation to canal walls, and their bioactivity may stimulate periapical healing. However, their removal during retreatment is more difficult compared with resin-based sealers.

3.5. 4.5 Other Sealers

Glass ionomer–based sealers offer chemical adhesion but suffer from poor handling and limited popularity. Silicone-based sealers are biocompatible but exhibit low bond strength and weak sealing capacity. As such, their clinical role remains marginal.

4. 5. RECENT EVIDENCE

The last decade has seen a surge in comparative studies evaluating sealer performance, with particular emphasis on the contrast between resin-based and bioceramic sealers.

4.1. 5.1 Laboratory Studies

Recent in vitro investigations confirm that bioceramic sealers achieve superior sealing ability compared to resin and ZOE-based sealers. Their capacity to form hydroxyapatite crystals along the dentin interface enhances bond durability. Push-out bond strength tests consistently report resin and bioceramic sealers outperforming ZOE.

Confocal microscopy has demonstrated deeper dentinal penetration for resin-based sealers, attributed to their lower viscosity. However, bioceramic sealers compensate through mineral infiltration and chemical bonding, which create a more stable long-term interface.

4.2. 5.2 Microleakage Studies

Fluid infiltration and bacterial leakage studies reveal bioceramic sealers provide significantly less microleakage than both resin and ZOE sealers over extended observation periods. Resin sealers still perform adequately in short-term evaluations but show higher leakage after thermocycling and mechanical loading compared to bioceramics.

4.3. 5.3 Clinical Relevance

While in vitro results strongly favor bioceramics, clinical extrapolation requires caution. Case series and preliminary clinical trials suggest comparable short-term success rates between resin and bioceramic sealers. However, the biological advantages of bioceramics, including antimicrobial pH and promotion of mineralized tissue deposition, suggest a potential for improved long-term outcomes.

Retreatment remains a practical limitation, as bioceramic sealers are harder to remove.

4.4. 5.4 Evidence Synthesis

Systematic reviews indicate that:

- Resin-based sealers remain the most widely adopted due to proven clinical track records.
- Bioceramic sealers show superior sealing performance and bioactivity, positioning them as the material of the future.
- ZOE sealers are now considered inferior in terms of adhesion and sealability, though they may still serve specific clinical roles in resource-limited settings.

5. 6. CLINICAL IMPLICATIONS

Sealer selection should be guided by both material properties and clinical context. Resin-based sealers remain dependable for their strong adhesion and long clinical history. However, their polymerization shrinkage and retreatment challenges may limit use in cases requiring future retreatment. Bioceramic sealers, with their bioactivity, dimensional stability, and chemical bonding, are increasingly favored, particularly for primary root canal treatments. They may enhance long-term outcomes by promoting healing and maintaining seal integrity, though retreatability remains a concern. ZOE sealers, while historically significant, offer limited advantages in contemporary practice. Ultimately, the choice of sealer must balance adhesion, sealability, biological interaction, and retreatment potential.

6. 7. CONCLUSION

Root canal therapy depends on the efficacy of sealers in providing long-term bonding as well as sealability. It has been shown that resin-based sealers have dependable micromechanical adhesion and low solubility, and calcium silicate-based sealers are better in terms of chemical bonding, bioactivity and long-term dimensional stability. The zinc oxide- eugenol sealers which were once important historically exhibit severe limitations owing to solubility and low adhesion. The choice of clinical decision-making should then be based on the biological advantages of the bioceramics versus the established reliability and retreatability of the resins. Recent findings indicate that there is a tendency towards using bioceramic sealers as the preferred option in most cases of endodontic procedures. However, the case of bioceramics requires the use of long-term randomized clinical trials before one can confirm the superiority in laboratory performance translates to clinical outcomes. So far, resin and bioceramic sealers are still at the center of the modern endodontic practice whereas traditional formulations have been deferred to a more minor position.

7. REFERENCES

Lee, K. W., Williams, M. C., Camps, J. J., & Pashley, D. H. (2002). Adhesion of endodontic sealers to dentin and gutta-percha. *Journal of endodontics*, *28*(10), 684-688.

Ferreira, I., Braga, A. C., & Pina-Vaz, I. (2021). Effect of Gutta-percha solvents on the bond strength of sealers to intraradicular dentin: A systematic review. *Iranian Endodontic Journal*, *16*(1), 17.

Singh, S. (2019). Vital pulp therapy: A Bio ceramic-Based Approach. *Indian Journal of Pharmaceutical and Biological Research*, *7*(04), 10-18.

Al-Ashou, W. M., Al-Shamaa, R. M., & Hassan, S. S. (2021). Sealing ability of various types of root canal sealers at different levels of remaining gutta percha after post space preparation at two time intervals. *Journal of International Society of Preventive and Community Dentistry*, *11*(6), 721-728.

Stoll, R., Thull, P., Hobeck, C., Yüksel, S., Jablonski-Momeni, A., Roggendorf, M. J., & Frankenberger, R. (2010). Adhesion of self-adhesive root canal sealers on gutta-percha and Resilon. *Journal of Endodontics*, *36*(5), 890-893.

Gad, R. A., Farag, A. M., El-Hediny, H. A., & Darrag, A. M. (2016). Sealing ability and obturation quality of root canals filled with gutta-percha and two different sealers. *Tanta Dental Journal*, *13*(4), 165-170.

Darrag, A. M., & Fayyad, D. M. (2011). Adhesives in endodontics. Part II: Role of adhesion in root canal obturation. *Endodontic Practice Today*, *5*, 87-105.

Baruah, K., Mirdha, N., Gill, B., Bishnoi, N., Gupta, T., & Baruah, Q. (2018). Comparative Study of the Effect on Apical Sealability with Different Levels of Remaining Gutta-Percha in Teeth Prepared to Receive Posts: An: in vitro: Study. *Contemporary clinical dentistry*, *9*(Suppl 2), S261-S265.

Singh, S. (2020). Irrigation Dynamics in Endodontics: Advances, Challenges and Clinical Implications. *Indian Journal of Pharmaceutical and Biological Research*, *8*(02), 26-32.

Kaul, S., Kumar, A., Badiyani, B. K., Sukhtankar, L., Madhumitha, M., & Kumar, A. (2021). Comparison of sealing ability of bioceramic sealer, AH Plus, and guttaflow in conservatively prepared curved root canals obturated with single-cone technique: an in vitro study. *Journal of Pharmacy and Bioallied Sciences*, *13*(Suppl 1), S857-S860.

Dsouza, A. P., Suvarna, N., Shetty, K. H., Farhana, F., & Syed, A. A. (2020). To compare and evaluate the sealing ability of GuttaFlow Bioseal, BioRoot RCS and MTA fillapex with AH plus: An in vitro study. *IOSR JDMS*, *19*, 43-9.

Singh, S. (2020). Deep Margin Elevation: A Conservative Alternative in Restorative Dentistry. *SRMS JOURNAL OF MEDICAL SCIENCE*, *5*(02), 1-9.

Karamchand, G., & Aramide, O. O. (2023). AI Deep Fakes: Technological Foundations, Applications, and Security Risks. *Well Testing Journal*, *32*(2), 165-176.

Nkansah, Christopher. (2023). Advanced Simulation on Techniques for Predicting Gas Behavior in LNG and NGL Operations. International Journal of Advance Industrial Engineering. 11. 10.14741/ijaie/v.11.4.1.

Karamchand, G., & Aramide, O. O. (2023). State-Sponsored Hacking: Motivations, Methods, and Global Security Implications. *Well Testing Journal*, *32*(2), 177-194.

Shaik, Kamal Mohammed Najeeb. (2022). Security Challenges and Solutions in SD-WAN Deployments. SAMRIDDHI A Journal of Physical Sciences Engineering and Technology. 14. 2022.

10.18090/samriddhi.v14i04..

Adebayo, Ismail Akanmu. (2022). ASSESSMENT OF PERFORMANCE OF FERROCENE NANOPARTICLE -HIBISCUS CANNABINUS BIODIESEL ADMIXED FUEL BLENDED WITH HYDROGEN IN DIRECT INJECTION (DI) ENGINE. Transactions of Tianjin University. 55. 10.5281/zenodo.16931428.

Olagunju, Joshua & Adebayo, Ismail Akanmu & Ovuchi, Blessing & Godson, Osagwu. (2022). Design Optimization of Small-Scale Hydro-Power Turbines for Remote Communities in Sub-Saharan Africa: A Nigerian Case Study.

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