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Review

A Comprehensive Review of the Sealing Abilities of Various Root Canal Sealers

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Abstract

Preventing oral flora and toxins from penetrating the root canal system and into the periapical tissues is the fundamental idea of successful root canal therapy. For this purpose, the entire root canal system, including the coronal and apical seals, must be obturated. Poor apical sealing allows bacteria to enter the root canal system and produce byproducts, or it allows tissue fluids to seep out, which can cause re-infection and endodontic treatment failure. Therefore, endodontic sealers are considered a cornerstone in the field of endodontics and are essential to the successful completion of root canal fills during obturation treatments. They resolve periapical inflammatory and/or infectious processes and prevent additional microbial contamination. A perfect endodontic sealer should have good adhesion to the canal walls, dimensional stability, insolubility against tissue fluids, sufficient setting time to guarantee working time and biocompatibility. Certain sealers, such as zinc-oxide-based, calcium hydroxide, glass ionomer, and resin, are clinically approved and frequently utilized, although no sealer possesses all of these qualities. Because of its decreased solubility, improved apical seal, microretention to root canal dentin, and decreased shrinkage, epoxy-resin-based sealers are utilized. Several research studies have demonstrated encouraging characteristics, particularly biocompatibility, antimicrobial qualities, and certain bioactivity of calcium-silicate based sealers. Zinc oxide eugenol sealer continues to be the most widely used sealer in many regions of the world.

Keywords: *root, canal, sealer, endodontic, ability*

Introduction

Root canal therapy involves a sequence of procedures aimed at addressing a tooth's infected canal, thereby halting the spread of infection and safeguarding the treated tooth from further microbial intrusion (1). The chemical and mechanical procedures, along with microbial management and complete sealing of the root canal system, are essential aspects of root canal preparation. Nevertheless, owing to the complex nature of the root canal system, complete sterilization cannot be achieved solely through mechanical tools and antibacterial rinsing. Consequently, bacteria persist within the dentinal tubules of the root. A canal devoid of microorganisms is the intent of endodontic therapy; for this reason, success with endodontic therapy over the long run depends on a well-obturated root canal (2). In the process of root canal therapy, the final step involves the sealing of the root canal system. This results in the creation of a permanent three-dimensional barrier from the apical foramen to the root canal opening. Gaps between the obturating substance and the root canal wall and incomplete closure may hamper apparent success in treatment (3).

Endodontic sealers are a well-established cornerstone in the field of endodontics and are essential to the successful completion of root canal fills during obturation treatments. In order to successfully complete root canal therapy, resolve periapical inflammatory and/or infectious processes, and prevent additional microbial contamination, these materials should have a specific set of properties (4). Grossman previously enumerated the characteristics of a perfect sealer in this context: to be observed through radiographic observation, the material must meet the following criteria: (a) exhibits adhesion when mixed to provide good adhesion to the canal wall; (b) creates a hermetic seal; (c) is radiopaque; (d) is a highly fine powder that can be easily mixed with liquid; (e) does not shrink on setting; (f) does not stain tooth structure; (g) is bacteriostatic or at least does not promote bacterial growth. (i) is soluble in a standard solvent, enabling its removal when needed; (j) is biocompatible, implying it has no potential to irritate periradicular tissue; and (k) is insoluble in host tissue fluids (5).

A crucial determinant of the enduring effectiveness of non-surgical root canal treatment lies in the choice of an endodontic sealer for practical application (6). When performing obturation, these sealers are utilized in the form of a slender, adhesive paste, serving the dual purpose of lubrication and cementing. This facilitates the smooth insertion and secure anchoring of the solid core obturation material, such as gutta-percha points, within the canal (7, 8). Sealers can be used to fill cavities, lateral canals, and auxiliary canals that are inaccessible to core obturation materials (9). If the sealer proves to be ineffective in carrying out its designated function, it can lead to microleakage, an imperceptible process involving the passage of bacteria, fluids, chemicals, or ions between the tooth and the restorative material. This, in turn, can contribute to the unsuccessful outcome of non-surgical root canal therapy (10, 11). Therefore, understanding the features and characteristics of sealers is essential in terms of selection and employment of the right endodontic sealer for each clinical instance.

Endodontic sealers are categorized based on their composition and setting reaction, which can be classified into the following groups: silicone, epoxy resin, tricalcium silicate, glass ionomer, and zinc systems. While these sealers predominantly consist of the mentioned sealer matrices, certain innovative sealers incorporate additional components like fillers or ceramic powders, such as calcium hydroxide, mineral trioxide aggregate, and calcium phosphate (9). In this paper, we aim to review and assess the sealing abilities of various sealers from the available evidence from the literature.

Methodology

This study is based on a comprehensive literature search conducted on November 3, 2023, in the PubMed, Web of Science, Science Direct, and Cochrane databases, utilizing the medical topic headings (MeSH) and a combination of all available related terms, according to the database. To prevent

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missing any possible research, a manual search for publications was conducted through Google Scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed the information about the sealing abilities of various root canal sealers. There were no restrictions on date, language, participant age, or type of publication.

Discussion

Teeth with endodontic treatment frequently have insufficient support for long-term restorations. Consequently, to achieve core retention for these teeth, an intra-canal post is frequently required. The material that is most frequently used to obturate a root canal is gutta percha cones and sealant. To achieve a fluid-tight seal, gutta percha is used with the sealer. A root canal sealer is essential for filling the voids and uneven areas within the main, additional, and side canals, as well as for sealing the space between the root canal wall and gutta-percha material (12). Better outcomes have been achieved over time as a result of improvements made to tools and materials used in several fields, most notably endodontics, owing to scientific and technological advancements. Nevertheless, none of the sealers have yet met all of Grossman's requirements. In actuality, several materials have been created, and they can be categorized based on their chemical makeup and structure (13). Some of the root canal sealers frequently employed in dental practice are discussed below.

Calcium silicate-based sealers

The use of calcium silicate-based materials has increased within the past 20 years. These compositions have been thoroughly studied and contrasted with traditional root canal sealers, like zinc oxide-eugenol and epoxy resin-based sealers. Several findings from in vitro research studies demonstrated their encouraging characteristics, particularly their biocompatibility, antimicrobial qualities, and certain bioactivity. However, clarification of the implications of their increased solubility is still needed since it may have an impact on their capacity to seal over the long run. Those sealers, which differ from conventional sealers in that they are hydraulic, have a setting that depends on the humidity level. In accordance with available evidence, the characteristics of sealers based on calcium silicate differ according to how they are made. Only a few modest studies have examined the therapeutic results of calcium silicate-based root canal sealers (14).

Calcium silicate-based sealers with high degrees of hydrophilicity and biocompatibility were introduced, capitalizing on the benefits of mineral trioxide aggregate. Water absorption and the dissolvability of root canal sealers are important factors that impact their stability, mainly due to the moisture-rich environment within root canals. Additionally, to withstand the dynamic conditions in the oral cavity, sealers must exhibit reduced microleakage and improved push-out bond strength. However, in practical application, traditional resin-based sealers continue to dominate even though their physical properties consistently meet the ISO criteria and they have been found to be biocompatible. Therefore, further research is necessary to enhance the physical attributes of calcium silicate-based sealers (15). Donnermeyer et al. stated that the minor solubility of materials based on calcium silicates even after setting contributes to the bioactive potential of these sealers; nevertheless, this solubility may also impair the effectiveness of sealing a root canal against regrowth and reinfection. To assess the therapeutic significance of the gap between bioactivity and solubility, more clinical research is needed (16).

Zinc-oxide eugenol sealers

Zinc oxide-based sealers are classified into two categories: eugenol-based and non-eugenol-based sealers. The primary component of all zinc-oxide eugenol-based sealers is zinc oxide. Certain zinc-oxide eugenol-based sealers include medicinal agents such as heavy metals, corticosteroids, and paraformaldehyde. Endomethasone, N2, Grossman's cement, Wach's cement, Rickert's formula, and others are examples of eugenol-based sealers. Examples of non-eugenol-based sealers are Kloropercha N-0 and SPAD (17). Long-term use of zinc oxide–eugenol sealers has proven successful in

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the past. If zinc oxide–eugenol sealers penetrate the periradicular tissues, they will absorb. However, they can discolor tooth structure and have a slow setting time, shrinkage on the setting, and solubility. Although the antibacterial action of this sealer group is a benefit, Rickert and Dixon were the first to introduce a zinc oxide–eugenol sealer. For radiopacity, this liquid/powder sealer included silver particles. Although the existence of lateral and accessory canals could be demonstrated, the sealer had the inherent disadvantage of causing tooth structure discoloration if not completely eliminated. Subsequently, the formulation was adjusted by removing silver particles to prevent staining. Furthermore, the formulation was improved further to produce a zinc oxide–eugenol catalyst/base sealer that is easy to combine and sets more quickly than liquid/powder sealers. Moreover, Tubli-Seal EWT provides prolonged working time. When employed with lateral compaction, Canada balsam, an ingredient in Wach's sealer (Balas Dental, Chicago, IL), gives the material a sticky or tacky quality that softens the gutta-percha into a more homogenous mass (18).

Zinc oxide eugenol sealer continues to be the widely used sealer in many regions of the world, despite the introduction of numerous sealers with positive outcomes throughout the years. Nevertheless, it has a number of intrinsic drawbacks, such as the release of hazardous substances and the processes of hydrolysis and disintegration. Reactions with the periapical tissue include necrosis, inflammation, and unfavourable tissue responses. The necessary qualities of zinc-oxide eugenol as a sealer have been continuously improved. This includes the release of medicinal sealers, zinc-oxide eugenol sealers that do not stain, and sealers that do not contain eugenol (19).

Epoxy-resin base

Epoxy resin-based sealers are considered the gold standard class of sealers since they exhibit minimal solubility, typically in compliance with general ISO requirements (20). In endodontic treatments, gutta-percha and root canal sealers with epoxy resin bases have been the most commonly utilized materials. Nonetheless, alternative methods and substances possessing distinct physicochemical and biological characteristics have been developed. Excellent physical characteristics of the epoxy resin-based sealers include low solubility, high flow rate, low volumetric polymerization contraction, and adaptability to the dentine walls of the canals (21). Low molecular weight epoxy resins and amines comprise epoxy resin-based sealers like AH 26 and AH Plus. Epoxide groups connected to the epoxy resins and amines react to produce a polymer. While AH Plus is present in a paste-paste mixture, AH 26 is in a powder-paste mixture (9).

Similarly, Rekha et al. narrated that they are frequently utilized in clinical practice because of their advantageous physicochemical properties and antibacterial action. However, it does not easily resorb when extruded into the periapical tissues and may cause a transient inflammatory response (22). Results from a meta-analysis determined that across all three examined root canals, the epoxy resin-based sealer exhibited a superior push-out bond strength when compared to the paste-to-paste calcium silicate-based sealer. Furthermore, within the middle third context, the epoxy resin-based sealer displayed a stronger push-out bond strength in contrast to the pre-mixed calcium silicate-based sealer for root canals (23). Brezhnev et al. reported that epoxy resin-based sealers' antimicrobial efficacy was generally enhanced by antimicrobial additions without impairing their physicochemical qualities, which were primarily compliant with ISO standards (24).

Numerous methods have been utilized in assessing microleakage, encompassing a range of techniques such as dye penetration, fluid filtration, glucose infiltration, microbiological leakage, and electrochemical leakage tests. Bouillaguet et al. reported that AH Plus showed a microleakage of 0.17 µL/min utilizing the fluid filtering method within the sixth hour of obturation, whereas GuttaFlow showed a microleakage of 0.08 µL/min. Thus, for this particular research study, GuttaFlow has 0.47 times the microleakage of AH Plus within the sixth hour (9, 25). AH Plus' performance was most closely achieved by salicylate resin sealers. Based on the cross-sectional

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stereomicroscopic study of extracted teeth, Apexit seals rather effectively in comparison to Zinc Oxide Eugenol, AH Plus, and RoekoSeal Automix. In a dye penetration research study, the salicylate-based sealer exhibited greater microleakage than conventional epoxy resin-based sealers, whereas zinc oxide eugenol sealers demonstrated more microleakage than AH Plus (9).

Bioceramic-based sealers

To seal root canal gaps, dimensionally stable bioceramic sealers have been developed. Zirconium oxide, calcium silicates, calcium phosphate monobasic, calcium hydroxide, and a thickening agent constitute these injectable and premixed hydrophilic calcium silicate and phosphate-based sealers. Bioceramic-based sealers rely on their hydrophilic and non-soluble properties to utilize the inherent moisture within dentinal tubules for both the initiation and completion of their setting reaction. The process through which bioceramic-based sealers adhere to dentin and establish mechanical connections through interlocking is termed tubular diffusion (22). In endodontics, bioceramic-based root canal sealants are thought to be a useful technology. It was discovered that sealers based on bioceramics were biocompatible and on par with other brand-name sealers. However, clinical results related to the usage of bioceramic-based root canal sealers are not well-established in the literature (26).

Kaul et al. demonstrated in their findings that the group that demonstrated the least amount of leakage was the TotalFill bioceramic sealer with bioceramic gutta-percha. The small particle size, hydrophilicity, and low contact angle of TotalFill bioceramic sealer, which allow the cement to travel readily over the dentin walls of the root canal and enter and fill the lateral micro canals, can be used to explain why it performs better. Both the related bioceramic particle-impregnated gutta-percha and the root canal dentin walls demonstrate chemical attachment to bioceramic root canal sealers. It also shows a noteworthy 0.20% expansion. These characteristics produce a chemical bond between the sealer and dentinal walls that is gap-free, which makes the sealer effective (27). While Pontoriero et al. concluded that when endodontically treated teeth are filled correctly using the warm gutta-percha procedure and a bioceramic sealer, the success rate is remarkably high (28). Our study provides insight into the sealing abilities of various endodontic/root canal sealers with evidence from recent literature, which is one of the strengths of our paper. However, we could not elaborately discuss the sealing abilities of each commercially available sealer. Additionally, a more comprehensive comparison among the sealers could also not be performed, which is one of the limitations of our study. However, we aim to assess and address them in our future successive research studies since it was beyond the scope of this study to discuss them in detail.

Conclusion

The effectiveness of endodontic or root canal treatment is significantly dependent on the sealing capabilities of a sealer, underscoring the critical importance of sealing ability for achieving optimal clinical results. A thorough understanding of the varying degrees of microleakage exhibited by these pertinent sealers can offer clinicians valuable information regarding the sealer's efficacy in preventing bacterial leakage, ultimately enhancing the likelihood of successful outcomes in endodontic procedures.

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There is no conflict of interest

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Data availability

Data that support the findings of this study are embedded within the manuscript.

Author contribution

All authors contributed to conceptualizing, data drafting, collection and final writing of the manuscript.

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References

1. Hargreaves KM, Cohen S. Cohen's pathways of the pulp: Elsevier; 2010.

2. Kelmendi T, Koçani F, Kurti A, Kamberi B, Kamberi A. Comparison of Sealing Abilities Among Zinc Oxide Eugenol Root-Canal Filling Cement, Antibacterial Bioceramic Paste, and Epoxy Resin, using Enterococcus faecalis as a Microbial Tracer. Medical science monitor basic research. 2022;28:e936319.

3. Javidi M, Zarei M, Naghavi N, Mortazavi M, Nejat AH. Zinc oxide nano-particles as sealer in endodontics and its sealing ability. Contemporary clinical dentistry. 2014;5(1):20-4.

4. Johnson W. KJC, Tay F. . Obturation of the Cleaned and Shaped Root Canal System. . in Hargreaves KM, Berman LH, editors Cohen's Pathways of the Pulp Elsevier; St Louis, MO, USA. 2016:280-322.

5. Grossman LI, Oliet S, Del Rio CE. Endodontic practice. (No Title). 1970.

6. Lee M, Winkler J, Hartwell G, Stewart J, Caine R. Current trends in endodontic practice: emergency treatments and technological armamentarium. Journal of endodontics. 2009;35(1):35-9.

7. Caicedo R, von Fraunhofer JA. The properties of endodontic sealer cements. Journal of endodontics. 1988;14(11):527-34.

8. Viapiana R, Guerreiro-Tanomaru J, Tanomaru-Filho M, Camilleri J. Interface of dentine to root canal sealers. Journal of dentistry. 2014;42(3):336-50.

9. Komabayashi T, Colmenar D, Cvach N, Bhat A, Primus C, Imai Y. Comprehensive review of current endodontic sealers. Dental materials journal. 2020;39(5):703-20.

10. Excellence ECf. Coronal leakage – Clinical and biological implications in endodontic success. 2002.

11. Kim SY, Kim KJ, Yi YA, Seo DG. Quantitative microleakage analysis of root canal filling materials in single-rooted canals. Scanning. 2015;37(4):237-45.

12. Al-Ashou WMO, Al-Shamaa RM, Hassan SS. Sealing Ability of Various Types of Root Canal Sealers at Different Levels of Remaining Gutta Percha After Post Space Preparation at Two Time Intervals. J Int Soc Prev Community Dent. 2021;11(6):721-8.

13. Fonseca DA, Paula AB, Marto CM, Coelho A, Paulo S, Martinho JP, et al. Biocompatibility of Root Canal Sealers: A Systematic Review of In Vitro and In Vivo Studies. Materials (Basel, Switzerland). 2019;12(24).

14. Sfeir G, Zogheib C, Patel S, Giraud T, Nagendrababu V, Bukiet F. Calcium Silicate-Based Root Canal Sealers: A Narrative Review and Clinical Perspectives. Materials (Basel, Switzerland). 2021;14(14).

15. Lim M, Jung C, Shin DH, Cho YB, Song M. Calcium silicate-based root canal sealers: a literature review. Restorative dentistry & endodontics. 2020;45(3):e35.

16. Donnermeyer D, Bürklein S, Dammaschke T, Schäfer E. Endodontic sealers based on calcium silicates: a systematic review. Odontology. 2019;107(4):421-36.

17. Rathi CH CM, Nikhade P, et. al Functions of root canal sealers- a review. J Evolution Med Dent Sci 2020;9(17):1454-8.

18. Johnson WT, Kulild JC. Chapter 10 - Obturation of the Cleaned and Shaped Root Canal System. In: Hargreaves KM, Cohen S, editors. Cohen's Pathways of the Pulp (Tenth Edition). St. Louis: Mosby; 2011. p. 349-88.

19. Vinola SMJ, Karthikeyan K, Mahalaxmi S. A novel petasin-modified zinc oxide eugenol sealer. Journal of conservative dentistry : JCD. 2019;22(5):490-4.

20. Silva EJNL, Cardoso ML, Rodrigues JP, De-Deus G, Fidalgo TKdS. Solubility of bioceramic- and epoxy resin-based root canal sealers: A

http://dx.doi.org/10.52533/JOHS.2023.31214

systematic review and meta-analysis. Australian Endodontic Journal. 2021;47(3):690-702.

21. Marques Ferreira M, Martinho JP, Duarte I, Mendonça D, Craveiro AC, Botelho MF, et al. Evaluation of the Sealing Ability and Bond Strength of Two Endodontic Root Canal Sealers: An In Vitro Study. Dentistry journal. 2022;10(11):201.

22. Rekha R, Kavitha R, Venkitachalam R, Prabath SV, Deepthy S, Krishnan V. Comparison of the sealing ability of bioceramic sealer against epoxy resin based sealer: A systematic review & meta-analysis. Journal of oral biology and craniofacial research. 2023;13(1):28-35.

23. Silva E, Canabarro A, Andrade M, Cavalcante DM, Von Stetten O, Fidalgo T, et al. Dislodgment Resistance of Bioceramic and Epoxy Sealers: A Systematic Review and Meta-analysis. The journal of evidence-based dental practice. 2019;19(3):221-35.

24. Brezhnev A, Neelakantan P, Tanaka R, Brezhnev S, Fokas G, Matinlinna JP. Antibacterial Additives in Epoxy Resin-Based Root Canal Sealers: A Focused Review. Dentistry journal. 2019;7(3).

25. Bouillaguet S, Shaw L, Barthelemy J, Krejci I, Wataha JC. Long-term sealing ability of Pulp Canal Sealer, AH-Plus, GuttaFlow and Epiphany. International endodontic journal. 2008;41(3):219-26.

26. Al-Haddad A, Che Ab Aziz ZA. Bioceramic-Based Root Canal Sealers: A Review. International journal of biomaterials. 2016;2016:9753210.

27. Kaul S, Kumar A, Badiyani BK, Sukhtankar L, Madhumitha M, Kumar A. 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. J Pharm Bioallied Sci. 2021;13(Suppl 1):S857-s60.

28. Pontoriero D, Cagidiaco E, Maccagnola V, Manfredini D, Ferrari M. Outcomes of Endodontic-Treated Teeth Obturated with Bioceramic Sealers in Combination with Warm Gutta-Percha Obturation Techniques: A Prospective Clinical Study. Journal of clinical medicine. 2023;12:2867.

http://dx.doi.org/10.52533/JOHS.2023.31214