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ROOT CANAL SEALERS- A COMPREHENSIVE REVIEW

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ABSTRACT

Root canal sealers are crucial components in endodontic therapy, ensuring the hermetic sealing of the root canal system. Their primary function is to fill the voids and irregularities between the dentinal walls and the core filling material, thereby preventing microleakage and subsequent reinfection. Various types of sealers, including zinc oxide-eugenol-based, calcium hydroxide-based, glass ionomer-based, resin-based, and bioceramic-based, have been developed, each with unique properties and clinical applications. The ideal sealer should exhibit excellent sealing ability, biocompatibility, antimicrobial properties, ease of handling, and radiopacity. Recent advancements have focused on enhancing the biological and physical properties of sealers, particularly through the incorporation of bioactive materials that promote healing and regeneration. Studies have shown that bioceramic sealers offer superior biocompatibility and the ability to form hydroxyapatite upon contact with tissue fluids, facilitating the repair and regeneration of periapical tissues. Additionally, the antimicrobial efficacy of sealers remains a critical factor in preventing endodontic treatment failures. Ongoing research is directed toward optimizing the formulations of sealers to improve their performance and clinical outcomes. This abstract underscores the

significance of root canal sealers in endodontics, highlighting the evolution of materials and the continuous quest for the ideal sealer to enhance the success rates of root canal treatments.

Historical Perspective

Root canal sealers have a long history in dentistry. Sealers have been in use since the early 19th century, when materials such as pure silver and gutta-percha were used to seal root canals.[4] Root canal sealers have evolved over time and been used in a range of different materials, each one with its own benefits and potential downsides.

It was only in the mid 20th century when the attention moved towards producing sealers that could seal the root canal system completely and leak-proof results were desired to ensure the success of endodontic treatments.[7] This research later led to new materials of zinc oxide-eugenol, calcium hydroxide-based sealers, and resin-based sealers.[7]

With further developments in research and technology, the properties of root canal sealers were improved to be biocompatible, antibacterial, dimensionally stable, and easy to handle. Consequently, the function of modern root canal sealers is particularly important to the sustained success of endodontic treatments providing an airtight seal and preventing recontamination of root canal systems.

Root canal sealers have been evolving through history revealing the advancement in the endodontic materials and techniques - emphasizing the importance of development and inquiry in advancing the quality and success of endodontic treatments.

INTRODUCTION

What is a root canal sealer?

According to Grossman, root canal sealers are used in conjunction with biologically acceptable semisolid or solid obturating materials to establish an adequate seal of the root canal system.[1]

According to Vimal Sikri, root canal sealers are defined as ‘binding agents used to fill the gap between the root canal wall and the obturating material’.[16]

Root canal filling is one of the most critical stages of endodontic treatment. Root canal sealers are crucial components in endodontic treatments, serving as fillers and adhesives in the complex root canal system. Endodontic literature has abundant articles supporting the fact

that gutta percha alone is not satisfactory to ensure the three dimensional seal of the root canal system.[2] It must be homogeneous and non-resorbable for it to provide fluid-tight seal of the root canal space, and hinder bacterial growth.[8] The root canal filling consists of a core, which is usually gutta-percha (GP), and a sealant.[2]

They are designed to fill voids, seal the spaces between the root canal walls and the core filling material, obturate the lateral canals and anastomoses and prevent microbial infiltration. Over the years, the development of root canal sealers has seen significant advancements. Early materials, such as zinc oxide-eugenol, were favoured for their sealing capabilities and antimicrobial properties.[13] However, they also had limitations, prompting the development of newer sealers like epoxy resin and glass ionomer, which offered improved physical and chemical properties.

The latest innovation in this field is the introduction of calcium silicate-based sealers, known for their hydrophilic nature, biocompatibility, and potential to promote healing.[3] Despite these advancements, each type of sealer comes with its own set of benefits and challenges, particularly regarding solubility and long-term sealing efficacy. Understanding the evolution and characteristics of these materials is essential for optimizing root canal treatments and improving patient outcomes. Ongoing research and clinical trials continue to shape the future of root canal sealers, aiming to enhance their properties and adapt to the ever-evolving demands of dental care. The sealer has an equally important or more importance than the core filling material in providing a successful outcome.[2]

Functions and Properties of Root Canal Sealers

1. *Antimicrobial property*- Root canal sealers have good antimicrobial properties. Microorganisms and their products cause pulpal and peri-radicular diseases due to poor irrigation and anatomical variations. Effective root canal debridement, antimicrobial irrigants, and antibacterial filling materials are crucial to eradicate microorganisms.[2,6] Bacteria present at the apical area may not be entombed, and would be eliminated by an antimicrobial endodontic sealer.[3]

2. *Lubricating property*- Root canal sealers in dentistry exhibit lubricating properties, aiding the gutta-percha in reaching the full length of the root canal for a comprehensive seal. Gutta-percha, being solid, requires these lubricants for better penetration. Various sealers like zinc oxide-eugenol, calcium hydroxide, resin, glass ionomer, bio-ceramic, and MTA-

containing sealers provide this essential lubrication, with zinc oxide-eugenol noted for its excellent lubricating properties.[6]

3. *Sealing capability*- The most common obturating material in root canal treatment is gutta-percha. However, gutta-percha does not adhere to the canal walls, making a sealer necessary to fill the space between the gutta-percha and the walls. Various obturating techniques are employed to improve the seal-ability of the root canal filling. Achieving a three-dimensional seal is crucial for successful root canal treatment in order to minimize microleakage. Sealers are essential for obtaining a perfect apical seal; they should be stable and non-irritating to tissues.[2,6]

4. *Biocompatibility*- One of the primary goals of endodontic treatment is to facilitate the repair of periapical tissues by inducing the formation of tissue similar to cementum. The biocompatibility of root canal sealers is critical because they come into direct contact with living tissues. The response of dental tissues to these sealers significantly influences the prognosis of endodontic treatment.[6,12]

5. *Bond strength*- The bond strength between root canal walls is demonstrated through micromechanical retention, which prevents the displacement of filling materials. This retention is crucial for maintaining the interface between the filling material and sealers. The push-out test is a method which is used to evaluate/measure the bond strength between filling materials and sealers.[6]

Ideal Requirements of A Root Canal Sealer[1,11]

1. It should be tacky when manipulated in order to provide good adhesion to the canal wall when set.
2. It should provide a hermetic seal.
3. It should be radiopaque so that it can be easily visualised on a radiograph.
4. The particles of the powder should be very fine so that they can mix easily with the liquid.
5. It should not shrink upon setting.
6. It should not stain tooth structure.
7. It should be bacteriostatic or at least not favour bacterial growth.
8. It should set slowly.
9. It should be insoluble in tissue fluids.

10. It should be tissue tolerant, that is, non-irritating to periradicular tissue.
11. It should dissolve in a common solvent, if necessary to remove the obturating material.
12. It should not provoke an immune response in the periradicular tissue.
13. It should be neither mutagenic nor carcinogenic.
14. It should be capable of bonding to dentin or gutta-percha / core filling material.

Classification of Root Canal Sealers

1. Based on their principal ingredient[1,2,11,14]

1. Zinc Oxide Eugenol based sealers- Rickert's formula, Grossman's cement, Roth's 801, Wach's cement, TubliSeal, IntraFill
2. Formaldehyde based sealer- Endomethasone
3. Iodoform based sealers- Iodoform paste, Vitapex
4. Calcium Hydroxide based sealers- Sealapex, Apexit, Apexit Plus, Vitapex, Calcibiotic root canal sealer
5. Resin based sealers- AH Plus, AH 26, Diaket, Diaket A, EndoREZ, Epiphany, Metaseal SE, Smartseal
6. Glass Ionomer based sealers- KetacEndo
7. Silicone based sealer- Roekoseal, Guttaflow, Lee Endofill
8. MTA based sealer- Endo CPM, ProRoot MTA, MTA Fillapex
9. Calcium-Silicate-Phosphate based bioceramic sealer- Endosequence BC, iRootSP, Bioaggregate

2. Messing's Classification[17]

1. Medicated sealers- Diaket, Endomethasone, N2
2. Eugenol based sealers- Silver containing (Kerr sealer), Silver-free (Grossman's, Tubliseal)
3. Non-eugenol-based sealers- Diaket, AH 26, EndoFill

3. Ingle's Classification[18]

1. Cements
2. Pastes
3. Plastics

4. Clark's Classification

1. Absorbable

2. Non-absorbable

Factors To Be Considered While Selecting A Root Canal Sealer

1) Amount of lubrication required
2) Anticipated working time
3) Temperature of core materials
4) Potential for irritation, if it is extruded into the periapical region
5) Presence or absence of periapical lesions
6) Choice of irrigants and intracanal medicaments
7) Antimicrobial action
8) Biocompatibility

Manipulation of Root Canal Sealers

Cements that are dispensed in the form of powder and liquid, are mixed on a sterile glass slab using a sterile spatula. Depending on the number of canals to be obturated, two or three drops of liquid are dispensed. Slowly, small increments of cement powder are added to the liquid while spatulating it to a smooth, creamy mix. The mixing time depends on the number of drops of liquid used.[1,11]

The completed mix can be tested for proper consistency by raising the flat blade of the spatula up from the mixed mass. The cement should '*string out*' for at least an inch from the glass slab before breaking.[1,11] Another method of testing the consistency of the mixed sealer is by ensuring the mix should cling to the inverted spatula blade for 10-15 seconds before dropping from the spatula.[1,11] After a satisfied mixing consistency is obtained, the cement is now coated into the dry root canal space.

Techniques of Placing Root Canal Sealer

Sealers can be placed in the root canal using the following techniques[2]

1) File
2) Reamer
3) Absorbent paper point
4) Lentulospiral
5) Master cone
6) Ultrasonic file
7) Pressure injection syringe

8) Bidirectional spiral

Using file, reamer, absorbent paper point

After mixing, the cement is introduced into the canal using a sterile, blunt smooth broach, absorbent point, or reverse-rotated reamer. Initially, the canal walls are coated using a lateral rotary motion, gradually moving the material towards the apex. Subsequently, a slow pumping motion is employed to ensure complete filling of the apical end and to expel any trapped air within the cement.[2]

Figure No. 1: Reamer.

Using lentulospiral

The sealer can be introduced into the canal using a slowly rotating lentulospiral. Initially, the plugger is inserted into the root canal with a small amount of sealer, without the engine running. Once inside, the engine is activated to coat the canal walls with the sealer. During withdrawal, the plugger is gently pressed against the canal wall to ensure even distribution of the sealer.[2]

Figure No. 2: Lentulospiral.

Using pressure injection syringe

The pressure syringe is a highly effective tool for placing sealer into the canal. It allows for complete filling of the canal using only sealer, eliminating the need for a solid core such as gutta-percha or a silver cone.[2]

Figure No. 3: Pressure injection syringe.

Advancements In Root Canal Sealers

Recent advancements in root canal sealers have greatly enhanced the success of endodontic treatments. Modern sealers are developed to improve biocompatibility, antimicrobial properties, and sealing effectiveness, addressing the drawbacks of older materials.[5] A notable innovation is the use of bioceramic sealers, which are very biocompatible and aid in the regeneration of periapical tissues. These sealers also provide excellent sealing capabilities by slightly expanding as they set, thereby reducing microleakage and increasing long-term success.[15]

Resin-based sealers have been enhanced to better adhere to dentin and resist displacement. They form a strong bond with both gutta-percha and canal walls, ensuring a durable seal.[9] Nanotechnology has enabled the incorporation of nanoparticles into sealers, boosting their mechanical strength and antimicrobial properties. These nanoparticles can penetrate dentinal tubules more effectively, ensuring a thorough seal and protection against bacterial infiltration.[3]

Additionally, the development of calcium silicate-based sealers has resulted in materials that can set in the presence of moisture and offer excellent biocompatibility and bioactivity. These

sealers can stimulate hydroxyapatite formation, further aiding the healing of periapical tissues.[16]

Overall, these advancements in root canal sealers contribute to more predictable and successful endodontic treatments, reducing the risk of treatment failure and improving patient acceptability and outcomes.

Clinical Implications and Future Prospects

Diagnosing pulp as vital or necrotic is imperative for selecting an appropriate endodontic sealer.[3] Regardless of the sealer used, a coronal seal provided by the final permanent restoration is essential for long-term clinical success. The quality of the coronal restoration is more critical to apical periodontal health than the technical quality of the endodontic treatment itself.[3] Currently, distinguishing sealer from gutta-percha on digital radiographs is challenging, limiting detailed observation. In the future, as the detection capability of clinical three-dimensional cone beam computed tomography (CBCT) systems (currently around 100 μm) approaches that of research-grade micro-CT machines (several μm), differentiating between gutta-percha and sealer and precisely observing unfilled spaces or voids will be possible.[3] Sealers and obturation techniques are expected to advance significantly with technological progress. The importance of sealers in preventing bacterial leakage and ensuring successful endodontic outcomes will become a greater focus in clinical practice.[3] Ideally, future sealers should provide a hermetic seal and offer therapeutic benefits.[8]

CONCLUSION

No sealer has yet been able to meet all clinical requirements on its own. There isn't a single material that can fulfil all needs simultaneously. Therefore, the selection of a sealer depends on the core material and obturation technique, which in turn are influenced by the root canal's anatomy. Additionally, the choice of sealer is impacted by pre-existing periapical conditions to ensure proper healing outcomes.

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