

BEHAVIORAL FACTORS AND CLINICAL DECISION-MAKING IN THE USE OF BIOCERAMIC SEALERS FOR ROOT CANAL TREATMENT**Moamen Abdelfadil Ismail^{1*}, Abdulrahman Hadi Alsalem², Mahmoud Jubran Jaber Almalki², Mazen Hussain S Alshahrani², Mohammed Raja Aloufi², Bassam Saud Alshaya²****¹Consultant at King Abdulaziz specialist hospital - Sakaka - Aljouf, ²General dentist****Abstract**

Background: Root canal treatment success relies heavily on effective obturation to seal the root canal system. Conventional resin-based sealers, such as AH Plus, have been widely used, but bioceramic sealers have emerged as a promising alternative due to their superior bioactivity, biocompatibility, and sealing properties. Despite their advantages, comparative clinical studies on their effectiveness remain limited. This study aimed to evaluate the efficacy of bioceramic sealers in enhancing root canal treatment outcomes compared to resin-based sealers.

Methods: A randomized controlled trial was conducted with 100 patients requiring primary endodontic treatment, randomly assigned to two groups: the experimental group (n=50) used a bioceramic sealer with the single-cone obturation (SCO) technique, while the control group (n=50) used AH Plus sealer with warm vertical compaction (WVC). Patients were followed for 12 months, with clinical and radiographic outcomes assessed at 3, 6, and 12 months. Primary outcomes included clinical success (absence of symptoms) and radiographic healing (reduction of periapical radiolucency). Secondary outcomes measured postoperative pain (VAS scores) and apical sealing ability (micro leakage). Statistical analyses included chi-square tests, t-tests, and Kaplan-Meier survival analysis.

Results: The bioceramic group demonstrated significantly higher clinical success rates at 12 months (95.8% vs. 76.6%, p=0.01) and superior radiographic healing (77.1% complete healing vs. 55.3%, p=0.02). Postoperative pain was significantly lower in the bioceramic group at all time points (p<0.008). Additionally, the bioceramic sealer showed better apical sealing, with 85.4% of cases exhibiting no micro leakage compared to 61.7% in the resin-based group (p=0.01).

Conclusion: Bioceramic sealers significantly improve root canal treatment outcomes, offering enhanced clinical success, periapical healing, and reduced postoperative pain compared to conventional resin-based sealers. Their superior sealing ability and biocompatibility make them a valuable alternative in modern endodontics. Further long-term studies are recommended to validate these findings and optimize their clinical application.

Keywords: Bioceramic sealer, Root canal treatment, AH Plus, Apical sealing, Postoperative pain, Endodontic success.

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Introduction

The primary objective of endodontic treatment is to achieve a properly sealed root canal system after thorough cleaning and shaping. However, anatomical complexities such as lateral canals, fins, and isthmuses pose challenges to achieving complete obturation, which is crucial for the success of root canal treatment (1-4). The effectiveness of endodontic therapy relies on both technical expertise and the quality of materials used, as inadequate sealing has historically been a major cause of failure (5-7).

Various obturation techniques have been developed to enhance the sealing ability of root canal treatments. The most commonly used methods include "cold" and "warm" gutta-percha condensation techniques, combined with a sealer that helps to fill voids, lubricate during the procedure, and seal accessory canals (8). Among these, warm vertical compaction (WVC) in combination with epoxy resin-based sealers, such as AH Plus, has been considered the gold standard due to its excellent sealing properties (9-10).

In recent years, bioceramic sealers have gained popularity in modern endodontics due to their superior physiochemical and biological properties (11). These sealers not only provide an enhanced sealing ability but also promote apical healing, exhibit antibacterial activity, and form chemical bonds with the tooth structure. The biological effectiveness of bioceramic sealers depends on their chemical composition and setting reaction, which involves hydration followed by the precipitation of calcium phosphate and the formation of hydroxyapatite (12).

One of the emerging techniques in endodontics is the single cone obturation (SCO) technique, in which a fitted gutta-percha cone is used along with a large volume of sealer. Historically, this technique has been considered inadequate due to its potential for apical leakage (13). However, with the introduction of hydraulic cement-based endodontic sealers, SCO has become widely accepted among general dentists and endodontic specialists for its ease of use and improved properties (14).

The success of root canal treatments is typically evaluated using clinical and radiographic criteria. Clinically, success is determined by the absence of symptoms and resolution of infection, while radiographic success is defined by the prevention, reduction, or elimination of apical radiolucencies (15). Studies assessing the success rates of root canal obturation with different types of sealers have been limited, with one non-randomized clinical trial evaluating the effectiveness of calcium silicate-based and resin-based sealers

in primary endodontic treatments (16). However, comparative studies on the success rates of different sealers in both primary and secondary endodontic treatments remain scarce.

Bioceramic sealers are designed to address many of the limitations associated with conventional sealers. They offer excellent biocompatibility, allowing for better periapical healing, and exhibit antimicrobial properties that help prevent reinfection. Additionally, their ability to chemically bond to dentin provides superior sealing, reducing the risk of micro leakage and enhancing the long-term success of root canal therapy (11,12).

Despite the promising advantages of bioceramic sealers, their clinical effectiveness remains underexplored in many regions. Most available studies have been conducted in controlled laboratory settings or limited clinical trials. The need for further clinical research is essential to determine their long-term success and compare their performance with conventional sealers in diverse patient populations (16).

Another critical aspect to consider is the influence of different obturation techniques on treatment outcomes when using bioceramic sealers. While WVC remains a widely accepted technique, its combination with bioceramic sealers needs further investigation to determine whether it provides superior outcomes compared to SCO or other obturation methods (9,14).

This study aims to evaluate the effectiveness of bioceramic sealers in improving root canal treatment outcomes. By assessing both primary and secondary endodontic treatments, the research will contribute to a better understanding of their role in enhancing periapical healing and overall success rates. Given the growing adoption of bioceramic sealers, establishing their clinical efficacy is crucial for advancing modern endodontic practices and optimizing patient care.

Methodology

This study adopted a randomized controlled trial (RCT) design to compare the effectiveness of bioceramic sealers with conventional resin-based sealers in enhancing root canal treatment outcomes. A prospective cohort model was used to evaluate treatment success based on both clinical and radiographic outcomes over a 12-month follow-up period. The study population consisted of patients who required primary endodontic treatment at dental clinics.

Inclusion Criteria

1. Adults aged 18-60 years who required non-surgical root canal treatment.
2. Teeth with vital or non-vital pulp diagnosed with irreversible pulpitis or necrosis.
3. Patients with adequate oral hygiene and no significant periodontal disease affecting the target tooth.
4. Single-rooted and multi-rooted teeth with intact periapical regions or mild apical periodontitis.

Exclusion Criteria

1. Patients with systemic conditions affecting bone healing (e.g., diabetes, osteoporosis).
2. Teeth with severe periodontal disease (probing depth >6mm).
3. Patients with a history of previous root canal treatment on the selected tooth.
4. Teeth with extensive root resorption or severe anatomical anomalies.
5. Pregnant or lactating women.

A total of 100 patients were enrolled and randomly assigned to two groups:

- Experimental Group (n=50): Root canal treatment using a bioceramic-based sealer.
- Control Group (n=50): Root canal treatment using a resin-based (AH Plus) sealer.

To account for potential attrition, an additional 10% of patients were recruited, ensuring that the study maintained an 80% statistical power with a significance level of $p < 0.05$.

A computer-generated randomization process was used to assign patients to the groups. The operator performing the treatment was not blinded, while the outcome evaluators were blinded to the treatment groups to minimize bias.

Intervention Protocol

All patients underwent standardized root canal therapy, which included the following steps:

1. **Anaesthesia & Isolation:** Local anesthesia was administered, and rubber dam isolation was applied.
2. **Access Cavity Preparation:** A standardized cavity was created using rotary burs.
3. **Cleaning & Shaping**
 - Root canals were shaped using NiTi rotary instruments up to size 30/.06 taper.
 - Irrigation was performed using sodium hypochlorite (NaOCl 5.25%), followed by EDTA (17%) for smear layer removal.
 - A final irrigation protocol with saline and chlorhexidine (2%) was applied.
4. **Obturation**
 - Experimental Group: Root canals were filled using a bioceramic sealer with the single-cone obturation (SCO) technique.
 - Control Group: Root canals were filled using an AH Plus resin-based sealer with warm vertical compaction (WVC).
5. **Coronal Seal & Restoration:** A temporary filling was initially placed, followed by a permanent composite restoration after one week.

Follow-Up and Outcome Assessment

Patients were evaluated at 3 months, 6 months, and 12 months after treatment.

Primary Outcome Measures

1. **Clinical Success**
 - Absence of pain, swelling, sinus tract, or tenderness on percussion.
 - No need for re-intervention or extraction.
2. **Radiographic Success**
 - Reduction or elimination of periapical radiolucency.

- No evidence of root canal failure (e.g., resorption, periapical lesions).

Secondary Outcome Measures

1. **Postoperative Pain (VAS Score):** Assessed at 24 hours, 48 hours, and 1 week post-treatment.
2. **Apical Sealing Ability:** Evaluated by analyzing microleakage in follow-up radiographs.
3. **Data Collection & Statistical Analysis**

Baseline Data: Collected at the start, including patient demographics, medical history, and tooth characteristics. **Pain Assessment:** The Visual Analog Scale (VAS) was used for pain evaluation. **Radiographic Evaluation:** Digital periapical radiographs were assessed using standardized criteria.

Statistical Analysis

Chi-square test was used for categorical variables. Independent t-test and ANOVA were used to compare continuous variables. Kaplan-Meier survival analysis assessed treatment success rates over time. A p-value of < 0.05 was considered statistically significant.

Results

This study evaluated the effectiveness of bioceramic sealers in enhancing root canal treatment outcomes by comparing them with resin-based sealers (AH Plus). A total of 100 patients were initially enrolled, with 50 patients in each group. However, 5 patients were lost to follow-up, resulting in a final sample size of 95 patients (48 in the bioceramic group and 47 in the resin-based group). The results were analyzed based on clinical success, radiographic healing, postoperative pain, and apical sealing ability at 3, 6, and 12 months (Table 1).

There was no significant difference between the two groups in terms of age, gender distribution, or tooth type ($p > 0.05$). The study population consisted of nearly equal numbers of males and females. Posterior teeth were more frequently treated in both groups (61.1%).

The bioceramic sealer group had a higher clinical success rate at all follow-up intervals. The difference became statistically significant at 12 months ($p = 0.01$), showing superior long-term outcomes for the bioceramic group. The resin-based group showed higher failure rates over time, possibly due to micro leakage and breakdown of the material. The bioceramic group demonstrated a significantly higher rate of complete healing (77.1%) compared to the resin-based group (55.3%) ($p = 0.02$). More patients in the resin-based group showed partial healing or no change in lesion size. These findings suggest that bioceramic sealers contribute to better periapical healing due to their bioactivity and sealing ability.

Patients in the bioceramic group reported significantly lower pain scores at all-time points. At 24 hours and 48 hours, the difference was highly significant ($p < 0.002$), suggesting that bioceramic sealers reduce postoperative inflammation. Even at 1 week, patients in the bioceramic group had less residual pain compared to the resin-based group. The bioceramic group had significantly better sealing ability, with 85.4% of cases showing no micro leakage compared to only 61.7% in the resin-based group ($p = 0.01$). The resin-based group had a higher rate of mild and severe micro leakage, which could lead to reinfection and treatment failure. These findings highlight the superior sealing ability of bioceramic sealers, likely due to their chemical bonding and hydroxyapatite formation.

Discussion

Bioceramic-based root canal sealers have emerged as a significant advancement in endodontics due to their bioactivity, biocompatibility, and sealing ability. Their use in clinical and in vitro studies demonstrates promising outcomes, particularly in improving the longevity and success rates of root canal treatments.

Table 1. Demographic and Clinical Characteristics of the Patients.

Characteristic	Bio ceramic Group (n=48)	Resin-Based Group (n=47)	p-value
Age (Mean ± SD)	35.6 ± 8.7 years	36.1 ± 9.2 years	0.72
Gender			
Male	23 (47.9%)	22 (46.8%)	0.88
Female	25 (52.1%)	25 (53.2%)	
Tooth Type			
Anterior Teeth	18 (37.5%)	19 (40.4%)	0.75
Posterior Teeth	30 (62.5%)	28 (59.6%)	

Bioceramic-based sealers exhibit desirable physicochemical properties, including high radiopacity, dimensional stability, and excellent sealing ability. Studies have shown that these sealers provide superior adhesion to dentin, ensuring a hermetic seal that minimizes micro leakage (Al-Haddad & Ab Aziz, 2016). This characteristic is critical in preventing bacterial reinfection, which remains one of the primary reasons for endodontic treatment failure.

Furthermore, their solubility is relatively low compared to conventional sealers, allowing for a more stable root canal obturation (Dong & Xu, 2023). However, some bioceramic sealers exhibit prolonged setting times, which may impact their clinical handling. Improving these properties through modifications in composition remains a challenge for future research.

One of the key advantages of bioceramic sealers is their biocompatibility. These materials are non-toxic and do not induce inflammatory responses when in contact with periapical tissues (Estivalet et al., 2022). Additionally, they exhibit bioactive properties by forming hydroxyapatite-like deposits on their surfaces when exposed to physiological fluids, which enhances their integration with the surrounding dentin.

The ability to induce mineralization is another crucial feature of bioceramic sealers. Estivalet et al. (2022) found that *in vitro* studies demonstrated the formation of carbonated apatite, which contributes to the regenerative potential of these materials. This bioactivity supports the healing of periapical lesions, further reinforcing their clinical value.

The antimicrobial efficacy of root canal sealers is essential in eradicating residual bacteria that survive chemo mechanical preparation. Bioceramic sealers exert their antimicrobial effect primarily through the release of hydroxyl ions, which create a high-pH environment unfavourable for bacterial survival (Suwartini et al., 2022). Studies have confirmed their efficacy against persistent endodontic pathogens, such as *Enterococcus faecalis* and *Candida albicans*, making them a reliable choice for reducing bacterial regrowth.

However, despite their antimicrobial potential, some research suggests that bioceramic sealers may not completely eliminate biofilms, necessitating additional disinfection protocols before obturation (Suwartini et al., 2022). Further studies are needed to enhance their antibacterial effectiveness through modifications in composition.

Compared to traditional sealers such as epoxy resin and zinc oxide-eugenol, bioceramic sealers demonstrate enhanced sealing properties and reduced cytotoxicity (Ortega et al., 2024). They are particularly advantageous in cases requiring long-term stability, as they do not degrade over time like some conventional materials.

Additionally, their ability to bond chemically with dentin rather than merely forming a mechanical interface ensures superior adhesion and reduces the risk of dislodgment over time (Ortega et al., 2024). However, their higher cost and specific handling requirements pose challenges for widespread adoption in clinical practice.

Various obturation techniques have been evaluated to determine the most effective approach for using bioceramic sealers. A study comparing different obturation methods in 3D-printed C-shaped root canals found that the single-cone technique combined with ultrasonic activation yielded the lowest void percentages and best adaptation of the sealer (Gharechahi et al., 2024). This technique enhances the flow of the material into complex root canal anatomies, ensuring optimal obturation.

Moreover, retrospective analyses of clinical cases using bioceramic sealers indicate high success rates. Lepure et al. (2024) reported that both EndoSequence BC sealer and NeoSealer Flo achieved over 94% success in root canal treatments, demonstrating their viability as effective endodontic sealers. The presence of periapical radiolucencies was identified as a significant prognostic factor affecting treatment success.

Despite the promising results associated with bioceramic sealers, there are areas that require further exploration. Research is needed to refine their mechanical properties, reduce setting time, and enhance antimicrobial activity (Dong & Xu, 2023). Additionally, more long-term clinical studies are required to establish their superiority over traditional sealers definitively.

Innovations in biomaterial engineering may lead to the development of next-generation bioceramic sealers with improved characteristics, such as enhanced bioactivity and faster setting times. These advancements will further optimize their performance and broaden their applicability in endodontic treatments.

Conclusion

Bioceramic-based root canal sealers represent a significant advancement in endodontic therapy, offering superior biocompatibility, bioactivity, and sealing ability. Their antimicrobial properties and long-term stability make them an excellent alternative to conventional sealers. However, further clinical trials

and material modifications are necessary to address existing limitations and maximize their therapeutic potential. As research progresses, bioceramic sealers are likely to play an increasingly vital role in modern endodontics.

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