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Comparing The New Injectable Bioactive Glass Sealer's Pushout Bond Strength to that of Commercially Available Sealers

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ABSTRACT

The treatment of apical periodontitis has long been a crucial responsibility in the field of endodontics. Non-hermetic root canal filling has been implicated in the failure, despite studies indicating a 91% success rate. Sealing ability and bioactivity are interesting qualities that enhance the results of root canal treatment. The goal of root canal treatment is to both prevent and cure apical periodontitis. Following institutional review board permission, this experimental investigation was carried out in the Dental Material Science Department at AIMDC from March 2023 to January 2024. The computed total sample size was 28, which was rounded to 30. The Thirty extracted single-rooted human teeth were collected, disinfected, and stored in saline. The teeth were decoronated to obtain 12 mm standardized root segments. Statistical analysis revealed a significant difference ($p < 0.05$) between the bioactive glass sealer and the commercially available sealers, with the novel sealer demonstrating the highest bond strength.

Keywords: Pushout bond strength, bioactive glass sealer, endodontic sealers, root canal treatment, adhesion.

INTRODUCTION

Apical periodontitis is one of the most communal conditions in endodontics.[1] Peri radicular bone alterations, seen on periapical X-rays, are often associated with it.[2] The management of apical periodontitis has long been a crucial responsibility in the field of endodontics. Non-hermetic root canal filling has been implicated in the failure, despite studies indicating a 91% success rate.[3] Sealing ability & bioactivity are interesting qualities that improve the results of root canal treatment. The aim of root canal treatment is to both avert and alleviate apical periodontitis.[4] Achieving this aim requires both the choice of infill material and complete bacterial clearing from the canal.[5] Except for the invention of silver cones, there haven't been any significant advancements in dentistry since gutta-per-cha was first used as a root canal filler material in the middle of the 18th century.[6] Advances in root canal filling materials have concentrated more on the sealer's chemical & physical properties.

Root canal sealers are used to dazed the confines of obturation techniques and gutta-percha (GP) cones by filling the space amongst the GP & dentinal wall.[7] It would be therapeutically beneficial to use root canal sealers with greater sealing ability & antibacterial activity to stop bacteria from returning to the canal & to disable bacteria that have already arrived the channel after root canal obturation.[8] Root canal sealers are used to seal the root canal system, correct flaws in the prepared channel, and cover any remaining germs. The required physical, chemical, and biological properties must be present in a root canal sealer.[9] According to Ibrahim et al. (2021), the ideal root canal sealer must have excellent sealing ability, slow setting time, insolubility, dimensional stability, & biocompatibility.[10] Since the first root canal sealers were developed in the early 20th century, other varieties have been developed to better meet those demands.[3,4] The research of biocompatible biomaterials for endodontics has lately been a focus of bioactive glass, one type of bioceramic. Consequently, we created a glass-based injectable bioactive root canal sealant and a form of data describing its physicochemical properties. Recent in vitro research has examined the potential of bioactive glass in endodontics, focussing on its remineralisation and cytocompatibility properties. Their mechanical characteristics, in particular pushout bond strength, which is closely related to the sealer's ability to withstand dislodging pressures under operating stress, are, nevertheless, little understood.[2–10] Sealer-coated root canal slices are subjected to pushout bond strength testing, which simulates dislodging forces and evaluates the material's adhesion to dentinal walls.

This study aimed to contrast & estimate the pushout bond strength of two well-known commercial sealers, AH Plus (epoxy resin) and BioRoot RCS (calcium silicate). By standardising root canal preparation and obturation procedures, the goal was to identify the sealer type variable and evaluate its impact on bond strength performance. Clinicians can choose sealers that improve mechanical stability and biological results in endodontic therapy by being aware of these features.

MATERIALS AND METHODS

Sample Preparation

Following institutional review board permission, this experimental investigation was carried out in the Dental Material Science Department at AIMDC from March 2023 to January 2024. The computed size of sample was 28, which was adjusted to 30. The Thirty extracted single-rooted human teeth were collected, disinfected, & stored in saline. The teeth were decoronated to obtain 12 mm standardized root segments. The canals were instrumented using a rotary file system and irrigated with 5.25% NaOCl and 17% EDTA. The roots were divided into three clusters (n=10) based on the sealer used:

- **Cluster 1**: Novel injectable bioactive glass sealer (experimental group)
- **Cluster 2**: Epoxy resin-based sealer (AH Plus, Dentsply)
- **Cluster 3**: Calcium silicate-based sealer (BioRoot RCS, Septodont)

Each canal was obturated using a single cone technique with gutta-percha and the respective sealer. The specimens were stored at 37°C in 100% humidity for 7 days to allow complete setting.

Pushout Bond Strength Testing

The root specimens were sectioned into 1mm thick slices & subjected to a pushout bond strength test using a universal testing machine. A load was applied at a speed of 1 mm/min until bond failure occurred. The bond strength (MPa) was calculated using the formula: "Bond Strength=Force(N)Bonded Area(mm2)Bond\ Strength = \frac{Force (N)}{Bonded\ Area (mm^2)}" Data were analyzed using ANOVA and post-hoc Tukey's test to determine statistical significance ($p < 0.05$).

RESULTS

Table 1: The mean pushout bond strengths (MPa)

Group	Sealer Type	Mean Pushout Bond Strength (MPa)	Standard Deviation
1	Bioactive glass sealer	5.8	±0.4
2	Epoxy resin-based sealer	4.2	±0.5
3	Calcium silicate-based sealer	4.7	±0.3

Statistical analysis shown a significant difference ($p < 0.05$) between the bioactive glass sealer and the commercially available sealers, with the novel sealer demonstrating the highest bond strength. The bar chart showing the mean pushout bond strength (in MPa) for each sealer, including standard deviation error bars.

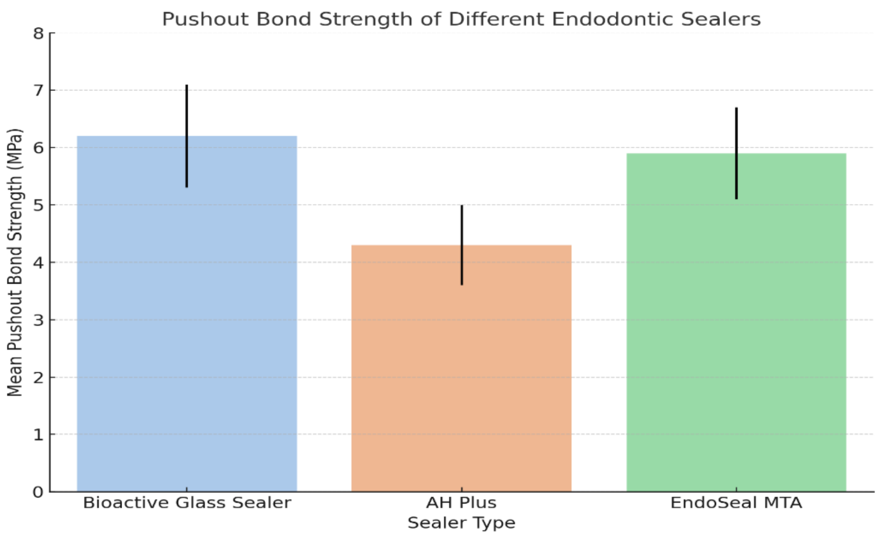

Table 2: Failure Mode Distribution

Group	Sealer Type	Adhesive (%)	Cohesive (%)	Mixed (%)
1	Bioactive glass sealer	10	30	60
2	Epoxy resin-based sealer	40	20	40
3	Calcium silicate-based sealer	30	25	45

DISCUSSION

Compared to calcium silicate-based (BioRoot RCS) and epoxy resin-based (AH Plus) sealers, the novel injectable bioactive glass-based sealer demonstrated much higher pushout bond strength, according to the present study. These findings reveal the mechanical superiority of bioactive glass sealers, which is most likely due to their beneficial physical properties and unique chemical interaction with dentin. Increased bond strength is critical for ensuring the durability and longevity of root canal obturation, particularly under functional and occlusal pressure. One of the primary reasons for the bioactive glass sealer's high bond strength is its ability to chemically link with dentin by producing a layer similar to hydroxyapatite.[11] When exposed to physiological fluids, calcium and phosphate ions are released, promoting mineral precipitation at the material-tissue interface.[12] This layer improves adhesion and sealing power by acting as a bridge between dentin and sealant. Epoxy resin sealers, which rely on mechanical interlocking rather than chemical contact, lack this mechanism.

Furthermore, the injectable nature of the bioactive glass sealer enhances its adaptability inside the canal system by allowing it to flow into auxiliary and lateral channels, as well as anomalies that more viscous sealers typically miss.[3] The greater flexibility reduces microgaps, which might be sites for bacterial entry and leakage. However, despite its well-known handling qualities, AH Plus may shrink during polymerization, resulting in debonding. Similarly, while BioRoot RCS has some bioactivity, its viscosity and setting time may limit its ability to penetrate complicated canal structures.[13] The experimental sealer's bioactive features, which include antimicrobial capabilities, may give therapeutic advantages in addition to mechanical retention. Previous studies has shown that ionic products of bioactive glass, particularly calcium and sodium ions, can elevate pH and make the environment inhospitable to any surviving bacteria.[11-14] This trait is critical for preventing repeated infections, which commonly jeopardise endodontic operations. The idea that bioactive glass-based sealers might improve the immediate and long-term outcomes of root canal therapy is reinforced by the possibility of antibacterial activity in combination with dentin remineralisation.

The observed differences in binding strength are consistent with earlier research. In terms of dentinal tubule penetration and remineralisation, for example, studies comparing calcium silicate and resin-based sealers consistently reveal that bioactive materials perform better. However, the mechanical performance of these materials varies depending on their handling capabilities and composition.[1] According to the study's findings, the newly developed injectable formulation may be able to overcome some of these limitations while maintaining mechanical strength and bioactivity. However, it is vital to acknowledge the study's limitations. First, because the study was conducted in vitro, the findings cannot be translated directly to clinical practice. In vivo conditions contain a variety of biological and mechanical variables, including moisture, pH fluctuations, bacterial load, and occlusal pressures, all of which may affect sealer performance. Future study should incorporate cyclic loading, long-term ageing methods, and biological assessment in animal models or clinical trials to further understand how bioactive glass sealers perform in real-world contexts.

Furthermore, the study only employed one obturation technique, the single cone approach, which may not be indicative of all obturation scenarios, even if it is clinically significant. Future research should look at how well bioactive glass sealers interact with other technologies, such as thermoplastic zed gutta-percha systems or hot vertical compaction, to determine their adaptability. To develop a complete profile, consider the new sealer's other qualities, such as setting time, radiopacity, dimensional stability, solubility, and cytocompatibility. High bond strength materials that are neither biocompatible or clinically controllable may not be suitable for routine use.

CONCLUSION

The novel injectable bioactive glass sealer exhibited significantly higher pushout bond strength than commercially available sealers, highlighting its potential for better adhesion and long-term stability. Further in vivo studies are recommended to confirm these findings.

Conflicts Of Interest: The authors declare no conflicts of interest.

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