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COMPARATIVE EVALUATION OF DIFFERENT SEALER PLACEMENT TECHNIQUES ON THE SEALING ABILITY OF BIOCERAMIC SEALER: AN EX VIVO STUDY

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ABSTRACT **Objective:** This study aimed to compare the sealing ability of Ceraseal sealer using three different placement techniques: Direct injection, Lentulo spiral, and Master gutta-percha cone. **Materials and Methods:** Forty freshly extracted single-rooted human teeth were selected, prepared, and instrumented up to the F3 ProTaper system. The canals were irrigated with 5.25% sodium hypochlorite and 17% ethylenediaminetetraaceticacid before being divided into three experimental groups (n=10) based on the sealer application technique: Group A (direct injection), Group B (Lentulo spiral), and Group C (master gutta-percha cone). Two control groups (n=5) were included. All teeth were obturated with F3 gutta-percha using the single cone technique. Dye leakage was assessed by submerging the apical 3 mm of samples in methylene blue dye for 24 hours, followed by longitudinal sectioning and examination under a stereomicroscope at 40x magnification to measure dye penetration using digital caliper, and the results were subjected to statistical analysis. **Results:** On applying a One-Way ANOVA, p-value was 0.001, indicating statistical significance. Tukey HSD post hoc analysis revealed no significant difference in dye leakage between Groups A and B (mean difference = -1.04, p = 0.097). However, Group A and B had a significantly higher dye leakage than Group C (with mean difference of A*C = 1.45, p = 0.015 and B*C = 2.49, p = 0.001). These findings confirm that Group C consistently showed the lowest dye leakage among the groups **Conclusion:** While none of the techniques achieved complete sealing, sealer placement with the Master gutta-percha cone technique demonstrated significantly least microleakage, ultimately indicating highest sealing ability among the groups

KEYWORDS : Ceraseal sealer, Dye leakage evaluation, Gutta-percha, Microleakage, Placement techniques, Sealing ability

INTRODUCTION

Achieving a uniform and tightly sealed root canal system is essential for successful endodontic therapy. Inadequate application of root canal sealer can lead to bacterial microleakage, compromising treatment outcomes.[4] Microleakage occurs when bacteria infiltrate the interface between the tooth and filling material, despite thorough root canal instrumentation. The ability of a sealer to penetrate dentinal tubules is critical in preventing this leakage, ensuring a fluid-tight seal that acts as a barrier against bacterial entry. This process is vital for filling voids, foramina, and canals, which ultimately leads to optimal treatment results.

Applying a thin, even coat of sealer on the canal walls before core filling is crucial. Over the years, significant advancements have been made in sealing materials, leading to the development of modern endodontic sealers. Ideal sealers create a tight seal at the apex, chemically bond with dentin, and expand slightly to enhance their fit against canal walls.

Recently, calcium silicate-based sealers have gained popularity due to their biocompatibility and interaction with dentinal moisture, which promotes the release of bioactive substances.[8] This interaction creates tag-like structures between the sealer and dentin, reinforcing the root structure when combined with gutta percha.[6] Ceraseal Bioceramic Sealer, for example, is a highly biocompatible material with a 3.5-hour setting time, good radiopacity, dimensional stability, and a high alkaline pH of 12.73. Its hydrophilic nature and ability to form tag-like structures ensure an excellent seal, reducing leakage and the risk of infection. Additionally, Ceraseal's antimicrobial properties, ease of use, moisture tolerance, and long-term stability make it a preferred choice for root canal treatments.

Different sealer placement techniques, such as using direct injection technique, file, lentulo spiral, absorbent point, gutta percha cone, and ultrasonic file, can influence sealer distribution and impact sealing effectiveness. Placement techniques selected in this study were direct injection technique, lentulo spiral technique, master gutta percha cone technique.

The direct injection technique involves injecting sealer directly into the prepared canal using a syringe or specially designed delivery system. This ensures precise and even distribution, reducing the risk of voids or gaps.

The Lentulo spiral is a flexible, stainless steel instrument used for even distribution of sealers. It is attached to a low-speed handpiece and rotated at 300-500 rpm, creating centrifugal force that propels the sealer apically while coating the canal walls.[1] This technique is efficient, allows for controlled application, and is time-saving.

In the master gutta-percha cone technique, the sealer is first applied to the canal walls, and then a master gutta-percha cone which sized to fit the canal, is inserted and coated with sealer. The cone's snug fit and the sealer's flow work together to fill any irregularities, providing an effective seal.

Given advancements in sealer technology and application techniques, evaluating the impact of different sealer placement methods on Ceraseal Bioceramic Sealer's sealing ability using dye leakage remains crucial. This study aims to enhance understanding and optimize practices for achieving superior sealing ability in endodontic therapy.

MATERIALS AND METHODS

Specimen Selection and Preparation

Forty freshly extracted human single-rooted teeth with straight canals and fully developed apices were selected for this study. The teeth were stored in 0.1% thymol solution for 24 hours to preserve the specimens. Ultrasonic scalers (Woodpecker UDS-P, Guilin Woodpecker Medical

Instrument Co., Ltd., China) were used to remove any calculus and residual soft tissue from the root surfaces.

Preparation of the Specimen

Access Opening and Canal Preparation: Access openings were created using an Endo Access Bur (Mani, Inc., Japan) with a high-speed airotor (NSK, Japan). The coronal third of the canal was prepared using Gates-Glidden Drills sizes 1, 2, and 3 (Mani, Inc., Japan). The working length was determined using an EndoBloc (Dentsply Sirona, Bensheim, Germany) and adjusted to be 1 mm short of the apex. A crown-down technique was employed using the X-Smart™ Endodontic Motor (Dentsply Maillefer, Switzerland) with the ProTaper Universal File System (Dentsply Maillefer, Switzerland) up to size F3.

To maintain apical patency, recapitulation was performed using a No. 10 K-file (Mani, Inc., Japan). The root canals were irrigated with 5 ml of 17% EDTA (Prime Dental Products Pvt. Ltd., India) alternated with 5 ml of 5.25% sodium hypochlorite (NaOCl) (Prime Dental Products Pvt. Ltd., India) after each file change. Finally, the canals were flushed with 5 ml of distilled water and dried with absorbent paper points (Dentsply Maillefer, Switzerland).

Group Allocation and Sealer Placement

The teeth were randomly divided into three experimental groups (n=10) based on the sealer placement technique used. Two additional groups served as positive and negative controls (n=5 each). Ceraseal (Meta Biomed Co., Ltd., South Korea) was used as the endodontic sealer.

Group A: Direct Injection Technique: For the direct injection technique, the intracanal placement tip provided by the manufacturer was used. The tip was attached to a syringe or specialized delivery system and inserted into the canal, injecting the Ceraseal sealer directly. Controlled pressure ensured the sealer filled the canal from the apex upward.

Group B: Lentulo Spiral Technique: In this group, a Lentulo Spiral (Dentsply Maillefer, Switzerland) was attached to a low-speed handpiece and rotated at 300-500 rpm. The instrument was inserted into the canal 3 mm short of the apex and rotated for 5 seconds per pump. This centrifugal force propelled the sealer apically while coating the canal walls. The spiral was withdrawn while still rotating to ensure thorough application.

Group C: Master Gutta-Percha Cone Technique: In this technique, Ceraseal sealer was dispensed onto a glass slab. The master gutta-percha cone (Dentsply Maillefer, Switzerland), sized to fit the canal, was coated with sealer and inserted into the canal to the working length in a clockwise motion. The cone was gently pressed into place, spreading the sealer evenly along the canal walls.

Control Groups:

Positive Control: The roots were coated with nail varnish, leaving the apical one-third exposed, and obturated with sealer without gutta-percha.

Negative Control: The entire root surface was coated with nail varnish, and no obturation was performed to ensure the complete seal by nail varnish against dye penetration.

Root Canal Obturation

Following sealer placement, the canals were obturated using the Single Cone Gutta-Percha technique. A pre-fitted F3 master gutta-percha cone (Dentsply Maillefer, Switzerland) was placed, and excess gutta-percha was sheared off with a heated instrument. The remaining gutta-percha was vertically condensed using a cold plugger. The access cavity was sealed with a temporary restorative material, CAVIT (3M ESPE, USA). Radiographs were taken to confirm the quality of the obturation. The teeth were then stored in 100% humidity at 37°C for 7 days to allow the sealer to set completely.

The roots were coated with two layers of transparent nail polish, leaving the apical 2 to 3 mm uncovered. The positive control group had roots coated with nail polish except for the apical 2 to 3 mm, while the negative control group had the entire root surface covered with nail polish.

After drying, the samples were placed in 12-ml vials containing 2% methylene blue dye solution (pH=7) (Sigma-Aldrich, USA) with the apex submerged for 24 hours. The samples were then rinsed, and the nail polish was removed with a scalpel blade.

Dye Leakage Evaluation

Each tooth was longitudinally sectioned using a hard tissue cutter (EXAKT 312, EXAKT Advanced Technologies GmbH, Germany) and examined under a stereomicroscope (Leica Microsystems, Germany) at 40X magnification to assess dye penetration.Linear dye penetration was measured from the apex using a digital caliper (Mitutoyo Corporation, Japan). The extent of dye leakage was computed using the ImageJ software (National Institutes of Health, version 1.53).

Statistical Analysis

Data were entered into Microsoft Excel 2007 and analyzed using SPSS statistical software (Version 23.0, IBM Corp., USA). The significance level was set at 5% The intergroup comparison was be done using the One Way ANOVA and Tukey HSD post hoc analysis.

RESULTS

Table 1: Intergroup Comparision Using One Way Anova Test

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
GROUP A	10	3.8300	.93101	.29441	3.1640	4.4960
GROUP B	10	4.8700	1.39766	.44198	3.8702	5.8698
GROUP C	10	2.3800	.81213	.25682	1.7990	2.9610
Total	30	3.6933	1.46921	.26824	3.1447	4.2419
p-value						0.001*

*p <0.005 is statistically significant

Table shows comparison of effect of sealer placement techniques between group A, group B and Group C respectively on applying One way Anova test based on collected data, final obtained P value was found to be 0.001 for all 3 groups which were statistically significant as mentioned as reference below the table 1.

Table 2: Post HOC Pairwise Comparison Of Dye Leakage Measurement

Multiple Comparisons						
Dependent Variable:						
Tukey HSD						
Group	Comparison Group	Mean Difference	Std. Error	P Value	95% Confidence Interval	
					Lower Bound	Upper Bound
Group A	Group B	-1.04000	.48165	.097 S	-2.2342	.1542
Group B	Group C	2.49000*	.48165	.001* S	1.2958	3.6842
Group C	Group A	-1.45000*	.48165	.015*NS	-2.6442	-.2558
*. The mean difference is significant at the 0.05 level.						

This table displays the results of a Tukey HSD post hoc analysis, comparing the mean differences in dye leakage between the groups. Group A and Group B showed a non-significant mean difference of -1.04 ($p = 0.097$), indicating no statistically significant difference in dye leakage between these two groups. However, Group A and B had a significantly higher dye leakage than Group C (with mean difference of A*C = 1.45, $p = 0.015$ and B*C = 2.49, $p = 0.001$). These findings confirm that Group C consistently showed the lowest dye leakage among the groups

The negative mean differences between Group C and the other groups confirm that Group C consistently exhibited the lowest dye leakage among the three groups. The significant p-values for comparisons involving Group C suggest a robust difference in dye leakage, particularly between Group C and the other groups.

DISCUSSION

The primary objective of root canal treatment is the thorough eradication of microorganisms from the root canal system, followed by sealing the canal to prevent reinfection.[3] Achieving this goal hinges on effective cleaning, shaping, and obturation of the canal, with the sealing process playing a critical role in ensuring long-term success. While various factors contribute to treatment outcomes, the sealer's properties and the technique used for its placement are of paramount importance.

The removal of the smear layer which is, a byproduct of canal instrumentation, is essential for facilitating the penetration of sealers into dentinal tubules. This process ensures the minimal entrapment of any residual bacteria, contributing to the prevention of reinfection. Sealers serve the critical function of filling the voids and irregularities between the gutta-percha cones and the canal walls, thereby enhancing the seal.

The choice of sealer and its application technique directly influence the success of root canal treatment. Calcium silicate-based sealers (CSBS), including Ceraseal, have gained attention for their hydraulic properties, biocompatibility, and bioactivity. However, the literature presents mixed findings regarding their dimensional stability, with some studies reporting no shrinkage upon setting, while others indicate slight expansion due to mineral layer formation.[8]

In the present study, three sealer placement techniques were compared: The direct injection technique, the Lentulo spiral technique and the master gutta-percha cone technique, using Ceraseal as the endodontic sealer.

Direct Injection Technique (Group A): This method resulted in a mean dye leakage of 3.83 mm, which was significantly lower than that of the Lentulo spiral technique but significantly higher than that of the master gutta-percha cone technique. This may be due the apical vapour lock phenomenon which lead to higher microleakage as observed in the studies done by Chen et. al in 2024[2] . While direct injection offers the advantage of controlled sealer placement, concerns remain regarding void formation and apical extrusion.

Lentulo Spiral Technique (Group B): This technique exhibited the significantly highest level of dye leakage among the groups, with a mean value of 4.87 mm. The centrifugal force generated by the Lentulo spiral may have contributed to the increased microleakage as observed. Factors such as the introduction of a larger sealer volume, potential shrinkage during setting, and the creation of voids due to air bubble inclusion likely played a role in these findings Our results align with the study findings of Tiwari et al. (2014),[9] who reported that the Lentulo spiral technique resulted in the significantly highest dye leakage among various sealer placement methods. Similarly, studies by Wiemann et al. (1992)[10] and Said et al. (2012)[7] found that the Lentulo spiral technique was associated with significant microleakage, though these studies did not find statistically significant differences among different methods. Variations in sealer type, canal anatomy, and other factors may account for the discrepancies between studies.

Master Gutta-Percha Cone Technique (Group C): This technique demonstrated significantly least dye penetration among the groups, with a mean value of 2.38 mm. The superior performance of this method may be attributed to the piston effect generated by the vertical forces during gutta-percha placement, which likely contributed to a more effective seal with reduced void formation. This finding is consistent with previous studies of Mathur et al. (2015)[5] and Said et al. (2012)[7], who reported that master gutta percha cone technique minimized microleakage more effectively than other techniques. The direct application of sealer onto the gutta-percha cone likely contributed to a thinner sealer layer with fewer voids, resulting in a more hermetic seal, which may have attributed to these results

While the Lentulo spiral technique was initially anticipated to provide superior sealer adaptation and uniform thickness, the present study suggests that this method may be prone to higher microleakage due to the dynamics of sealer application and volume. In contrast, the master gutta-percha cone technique demonstrated a more reliable seal, making it a preferable choice in clinical practice.

The master gutta-percha cone technique demonstrated the most effective seal among the three sealer placement methods evaluated, with the least microleakage observed. The direct injection technique showed moderate effectiveness, while the Lentulo spiral technique exhibited the highest level of dye penetration, indicating greater susceptibility to microleakage. These findings emphasize the importance of selecting appropriate sealer placement techniques to optimize the outcomes of root canal treatment. Further research is warranted to explore the long-term clinical implications of these techniques.

Limitations

This investigation is conducted ex vivo, which may not entirely mimic clinical conditions, thereby potentially restricting the replicability of the intraoral environment. Additionally, the emphasis on short-term sealing efficacy leaves the assessment of long-term performance unaddressed.

Clinical Significance

By minimizing microleakage, the master gutta-percha cone technique may optimize the sealing ability of ceraseal and thereby, reduce the likelihood of post-treatment complications.

CONCLUSION

This research aimed to assess different sealer placement methods' impact on Ceraseal's sealing ability using dye leakage evaluation in vitro. While none of the techniques achieved complete sealing, results indicated that the Lentulo spiral technique showed the highest dye leakage, followed by direct injection, whereas, the Master gutta percha cone placement technique demonstrated the lowest level of dye penetration, indicating that this method minimizes microleakage and maximizes sealing capability among the tested techniques.

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