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Effect Of Exposure Of Etidronic Acid, Sodium Hypochlorite And E.D.T.A. On The Bond Strength Of Calcium Silicate Based Cements– An In Vitro Study

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ABSTRACT

Objective:

This study aims to evaluate and compare the Effect of exposure of Etidronic acid, Sodium Hypochlorite and E.D.T.A on the bond strength of calcium silicate based cements– An in vitro study

Materials and method:

180 sections (2 mm thick) of coronal root dentin were obtained from roots of 180 extracted teeth; the canals were enlarged to a standardized perforation cavity diameter of 1.4 mm. Sections were randomly divided into 2 groups (n = 90 per group), and cavities were filled with ProRoot mineral trioxide aggregate (MTA) and Biodentine™ according to the manufacturers' instructions. . Each group was further divided into subgroups exposed to different root canal irrigants: 5.25% Sodium Hypochlorite (NaOCl) alone, NaOCl with 17% EDTA, and NaOCl with 18% Etidronic acid (HEBP). The specimens were analyzed after 1 day and 21 days for Push-out bond strength. The values were measured using a universal testing machine under a compressive load at a speed of 1 mm/min. Data were analyzed using one-way analysis of variance test at a significance level of $p < 0.05$.

Result:

A statistically highly significant difference (p-value < 0.05) between sodium hypochlorite and sodium hypochlorite with Etidronic acid in ProRoot MTA at day 1, and a statistically significant difference (p-value < 0.05) between sodium hypochlorite and sodium hypochlorite with Etidronic acid in Biodentine at both day 1 and day 21.

Conclusion:

This present study designed to assess Push Out Bond Strength (POBS) immediately after exposure of the cements to RCIs at two different setting times, suggests that NaOCl + HEBP may be a suitable irrigant for use shortly after repairing a perforation with Calcium Silicate Based Cements (CSBC), as it does not appear to negatively affect the bond strength of these materials.

Key Words: Calcium silicate-based materials, Mineral trioxide aggregate, Push-out bond strength, Root repair materials, Biodentine

Introduction:

Successful root canal treatment hinges on thorough cleaning, eradication of pathogens, and three-dimensional filling to prevent microbial re-entry. During preparation, an iatrogenic smear layer forms on dentinal walls, consisting of inorganic and organic materials, including bacteria and tissue debris. Removing this layer enhances clinical outcomes. Sodium hypochlorite (NaOCl) is effective at dissolving organic tissue but not inorganic components, necessitating the use of ethylenediaminetetraacetic acid (EDTA) for comprehensive cleaning(1).

Immediate repair of root perforations is crucial to prevent contamination and potential complications. Calcium silicate-based cements (CSBC), such as Mineral Trioxide Aggregate (MTA)(2), are commonly used for repair, though they have limitations like long setting times and potential for tooth discoloration. NeoMTA Plus and Biodentine (BD) have been developed to address these issues, offering better handling, reduced discoloration, and improved sealing(3).

During root canal treatment, repairing materials are exposed to irrigants like NaOCl, EDTA, and etidronic acid (HEBP). Dual Rinse HEDP combines NaOCl and HEBP for effective irrigation.(4) Contact with these irrigants can influence the bond strength of CSBC, impacting treatment outcomes. Effective instrumentation, irrigation, and sealing are critical for successful root canal therapy.(3)

Despite its effectiveness, EDTA has limitations, including cytotoxicity, reduced efficacy in removing the smear layer from the apical third, and decreased dentin microhardness. Over time, alternative chelating agents have been introduced with varying success. Studies have shown that AH Plus and Epiphany exhibit higher push-out bond strength (POBS) values when used with 1% NaOCl and 17% EDTA compared to EDTA alone.(5)

Etidronic acid (1-hydroxyethane 1,1-diphosphonic acid, HEBP) is a less aggressive chelator that can be used with sodium hypochlorite without compromising its antimicrobial properties(6). Research indicates that AH Plus demonstrates significantly higher POBS when used with NaOCl and HEBP compared to NaOCl and EDTA.

While the effects of different chelating agents on the bond strength of MTA-based sealers are well-documented, the impact of compositional modifications on push-out bond strength is not widely reported.

This study aims to evaluate and compare the effects of Sodium Hypochlorite, Ethylenediaminetetraacetic acid (EDTA), and Etidronic acid on the bond strength of calcium silicate-based cements. Specifically, the primary objective is to assess the impact of Sodium Hypochlorite on the bond strength of Mineral Trioxide Aggregate (MTA), particularly ProRoot MTA (PMTA; Dentsply-Sirona) and Biodentine (BD; Septodont). The secondary objectives include evaluating the combined exposure of Sodium Hypochlorite and EDTA on the bond strength of MTA and Biodentine, assessing the combined exposure of Sodium Hypochlorite followed by Etidronic acid on the bond strength of MTA and Biodentine, and comparing the effects of Sodium Hypochlorite, EDTA, and Etidronic acid on the bond strength of MTA (ProRoot MTA) and Biodentine.

Method:

A total of 180 extracted teeth were evaluated using digital radiography, decoronated with a diamond disc, and assessed to ensure they had single, non-calcified canals without radicular caries, resorptions, or visible cracks. The teeth were cleaned of soft tissue and calcified debris using manual scaling, then stored in a 0.9% saline solution at 4°C. From each tooth, a 2 mm thick root slice was obtained from the coronal portion, resulting in 180 dentine slices.

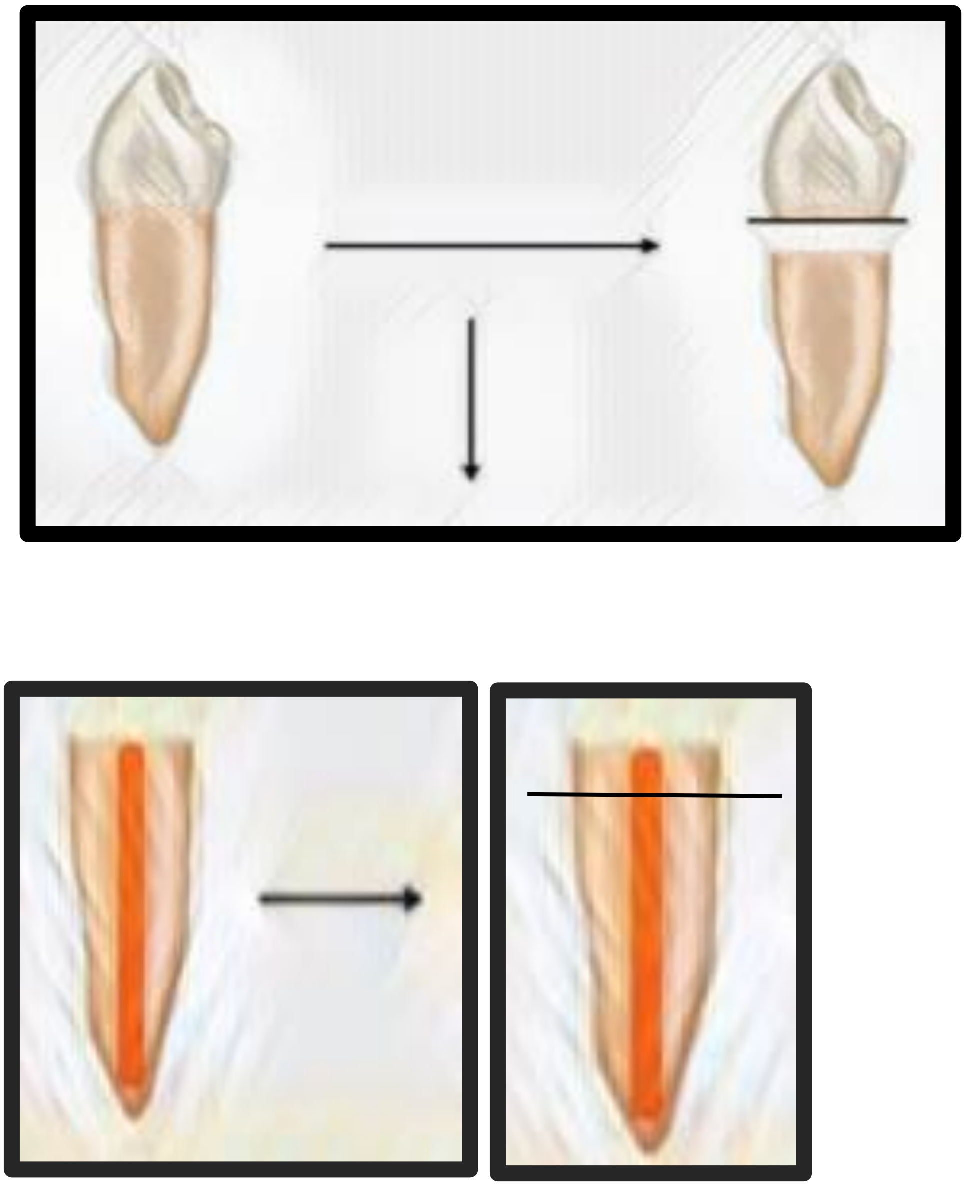

Figure 1: schematic representation of Decoronation and root slice preparation

A 1.4 mm circular perforation was drilled in the center of each slice using a BR-41 FG bur. The specimens were divided into two groups: Group 1 (90 slices) filled with ProRoot Mineral Trioxide Aggregate (PMTA) and Group 2 (90 slices) filled with Biodentine.

Both materials were mixed and placed according to manufacturers' instructions, with excess material removed from the surface. The samples were wrapped in wet gauze, incubated at 37°C with 100% humidity, and allowed to set for 10 minutes. Each group was further divided into subgroups exposed to different root canal irrigants: 5.25% Sodium Hypochlorite (NaOCl) alone, NaOCl with 17% EDTA, and NaOCl with 18% Etidronic acid (HEBP).

The specimens were analyzed after 1 day and 21 days, with 0.2 ml of irrigant applied every 5 minutes for a total of 30 minutes. The slices were then placed in custom metal rhomboidal steel frames and subjected to push-out bond strength testing using a universal testing machine.

The punch was incrementally advanced towards the repair material at a consistent crosshead velocity of 1 mm/min. The maximum force (F) required for the punch to displace the material was recorded in Newtons, and the Peak Overload Bond Strength (POBS) was subsequently computed in Megapascals

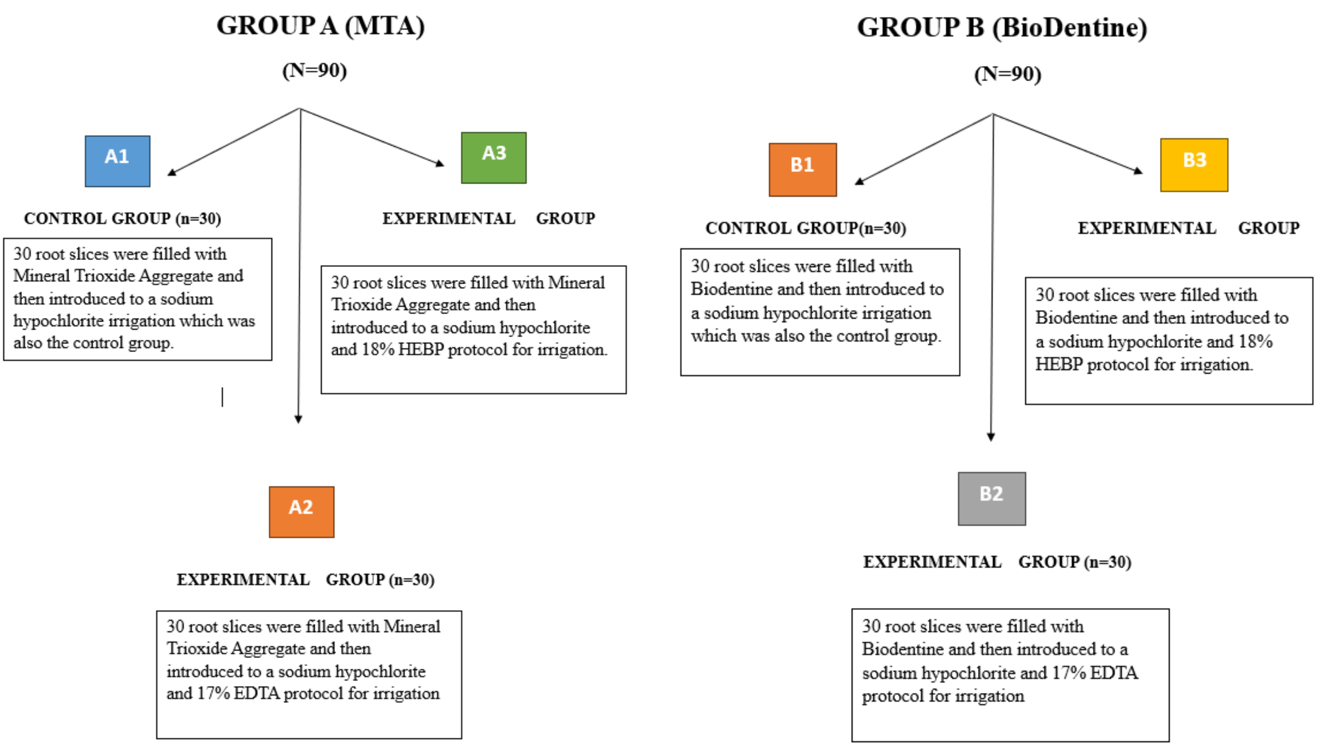

Figure 2: Division of groups and sub groups

The push-out bond strength (POBS) will be calculated using the formula: POBS (MPa) = F (N) / S (mm²), where S represents the contact surface area between the dentin and the material. The contact surface area (S) is determined by the equation: $S = 2 \times r \text{ (mm)} \times \pi \times h \text{ (mm)}$, where r is the radius of the perforation, π is the constant 3.14, and h is the thickness of the section

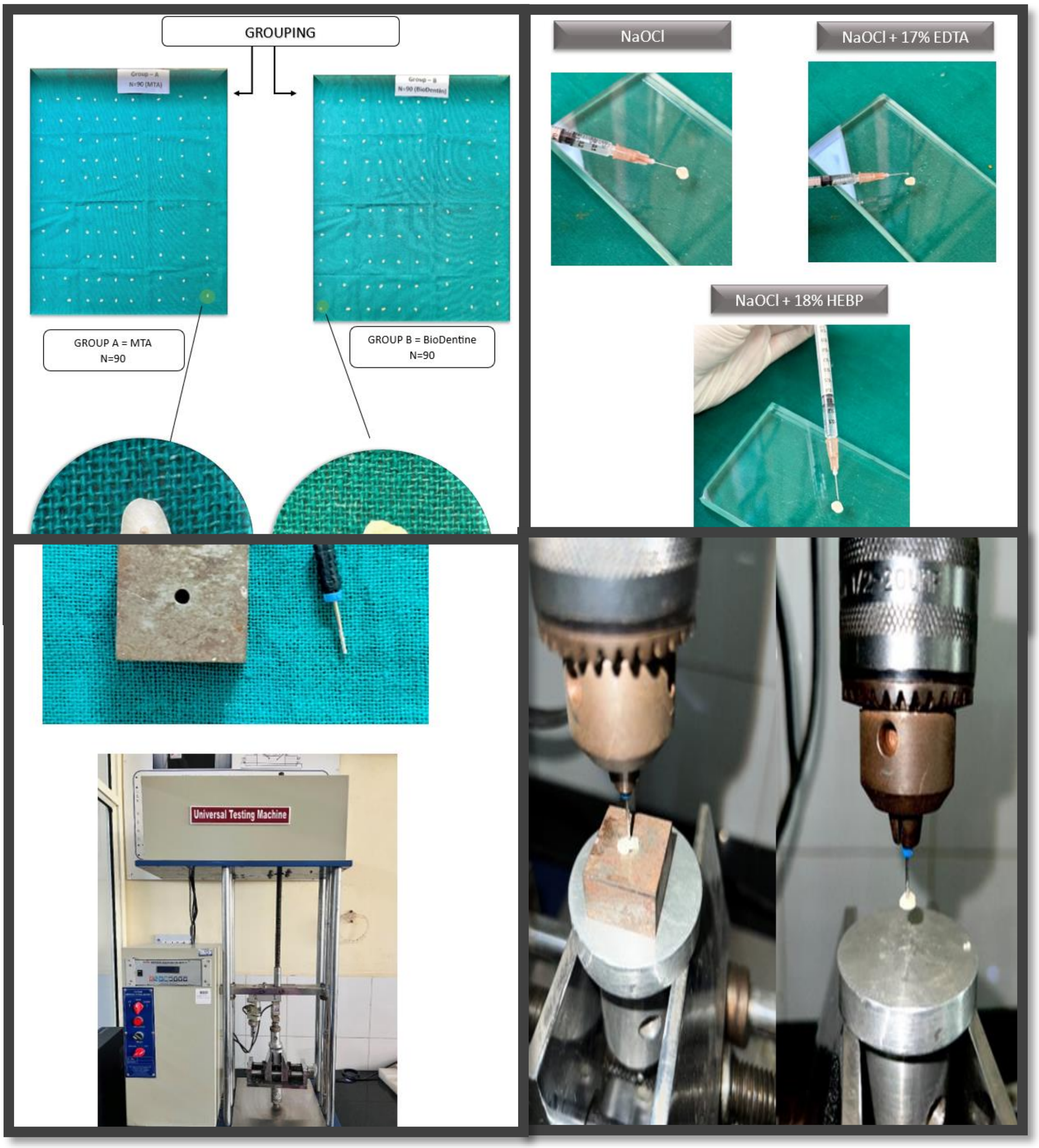

Figure 3: a) decoronation of the root slices and filled with CSBC
b) Standard Irrigation protocol simulated with different irrigants
c) Testing with Universal Testing Machine
d) testing for Push out bond strength

Results:

In the present study, a comparison of push-out bond strength was conducted between ProRoot MTA and Biodentine using three different root canal irrigants: sodium hypochlorite, sodium hypochlorite with EDTA, and sodium hypochlorite with Etidronic acid, at both day 1 and day 21. The results were found to be statistically highly significant (p-value < 0.05) using a one-way ANOVA test for both ProRoot MTA and Biodentine at both time points.

Multiple comparisons revealed statistically highly significant differences (p-value < 0.05) between sodium hypochlorite and sodium hypochlorite with EDTA in both ProRoot MTA and Biodentine at day 1 and day 21.

There was also a statistically highly significant difference (p-value < 0.05) between sodium hypochlorite and sodium hypochlorite with Etidronic acid in ProRoot MTA at day 1, and a statistically significant difference (p-value < 0.05) between sodium hypochlorite and sodium hypochlorite with Etidronic acid in Biodentine at both day 1 and day 21.

Additionally, statistically significant differences (p-value < 0.05) were found between sodium hypochlorite with EDTA and sodium hypochlorite with Etidronic acid in both ProRoot MTA and Biodentine at both day 1 and day 21.

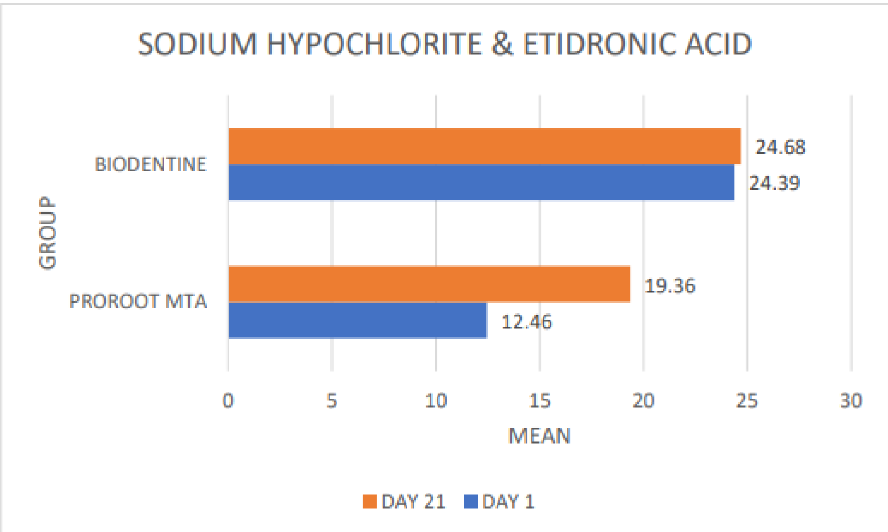

Figure 4 : INTRACOMPARISON OF SODIUM HYPOCHLORITE & ETIDRONIC ACID

Discussion:

Root perforation during endodontic procedures is a critical issue that requires immediate and effective repair to prevent complications such as contamination of the periodontal ligament and extrusion of root canal irrigants or filling materials.(7) Repairing the perforation before root canal treatment is essential to avoid endodontic-periodontal lesions, epithelial attachment damage, and bone loss. (8)

Dental perforations, unintended openings in the tooth, are susceptible to infection and inflammation from surrounding tissues. Prompt recognition and management of dental perforations are crucial to minimize further complications and ensure the best possible outcome for the patient.

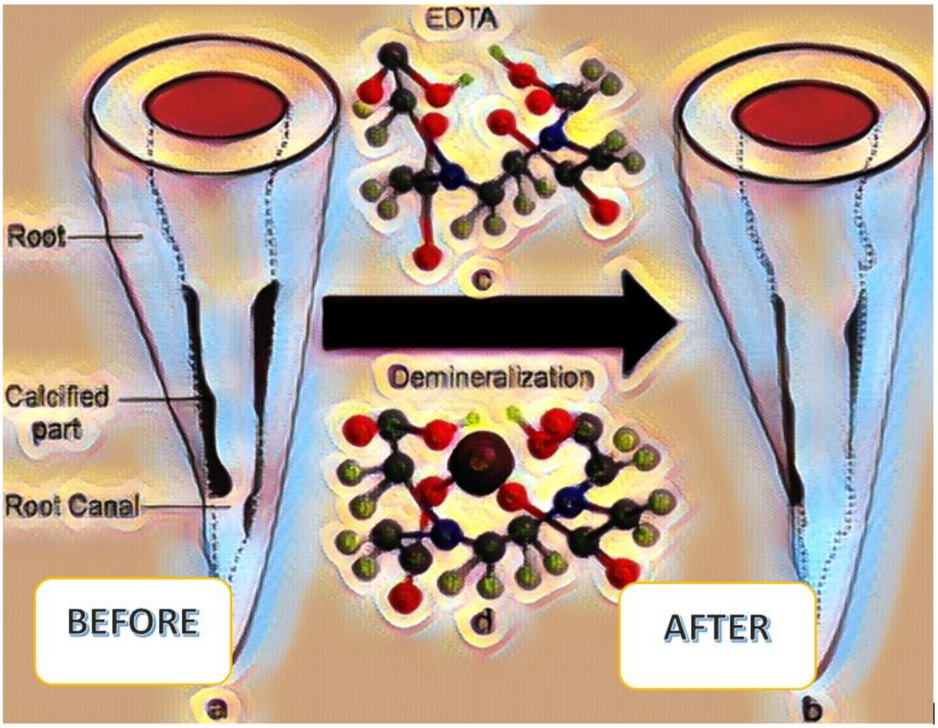

Figure 5: schematic representation of Mechanism of action of EDTA

Ideal Perforation Repair Material Properties:

An ideal perforation repair material should possess biocompatibility, sealing ability, adhesion, radiopacity, good setting time and working time, strength and resistance to dissolution. (4,7)

Mineral Trioxide Aggregate (MTA):

MTA is a widely accepted material in endodontics, especially for perforation repair. Composed primarily of tricalcium silicate, it has exceptional sealing ability, biocompatibility, and bioactivity. Upon contact with moisture, MTA forms hydroxyapatite crystals, creating a hermetic seal that prevents microleakage and promotes tissue healing and dentin adhesion. (2) Its radiopacity further contributes to its reliability. Despite its long setting time (2-4 hours), MTA's clinical versatility and effectiveness make it invaluable in endodontic procedures.

Biodentine:

Biodentine, a bioactive dentin substitute, is gaining attention for its versatility and clinical outcomes. Composed of tricalcium silicate, calcium carbonate, and zirconium oxide, it stimulates dentin-like tissue formation and promotes pulp healing. Its hydraulic properties enable rapid setting and high compressive strength, making it suitable for various clinical applications, including perforation repair (3). Biodentine's compressive strength (200-300 MPa) is higher than MTA (70-80 MPa), making it particularly suitable for high-strength applications. Its composition closely resembles natural dentin, contributing to its success in restorative dentistry.(9)

Root Canal Irrigants:

Root canal irrigants play a crucial role in endodontic therapy by aiding in the mechanical and antimicrobial debridement of the root canal system. Common irrigants include sodium hypochlorite (NaOCl), chlorhexidine (CHX), and ethylenediaminetetraacetic acid (EDTA)(10). NaOCl is preferred for its antimicrobial properties and tissue dissolution ability. EDTA is used primarily for its chelating properties, facilitating the removal of inorganic debris and the smear layer.(11)

NaOCl is the gold standard due to its broad-spectrum antimicrobial activity, tissue dissolution ability, and smear layer removal. EDTA is used to remove the inorganic component of the smear layer and expose dentinal tubules(10). A combination of NaOCl and EDTA is commonly employed for its synergistic effects in cleaning and disinfecting the root canal system.(12)

Push-Out Bond Strength (POBS):

The push-out bond strength of calcium silicate-based materials is crucial for the durability and longevity of restorations(13). MTA and Biodentine have been extensively studied, with Biodentine generally exhibiting higher compressive strength.(9,14) The combination of NaOCl and EDTA can impact the POBS of root canal filling materials, with NaOCl alone or in combination with EDTA showing variable effects on bond strength.(15) (19)

Etidronic Acid:

Etidronic acid is a promising alternative to EDTA for root canal irrigation. It offers effective chelation properties without excessive dentin demineralization, preserving tooth structure. Studies suggest that etidronic acid can enhance the push-out bond strength of calcium silicate-based materials by maintaining dentin integrity and optimizing adhesion properties(8).

Previous research has demonstrated that preconditioning dentin with a combination of NaOCl and HEBP can enhance the Push-Out Bond Strength (POBS) of calcium silicate-based materials (16) . A recent study, similar to ours in methodology, investigated the impact of NaOCl + HEBP and other root canal irrigants (RCI) on the POBS of various Calcium Silicate-Based Cements (CSBC) after 7 days of setting (4). It was found that HEBP + NaOCl might increase POBS values for Biodentine (BD) but not for ProRoot MTA (PMTA). Our study's findings are consistent with this observation after 1 day of setting for BD; however, they diverge after 21 days. (17)

Effective management of root perforations and selection of appropriate repair materials and irrigants are critical for the success of endodontic treatments. MTA and Biodentine are valuable materials for perforation repair, each with unique properties that contribute to their effectiveness. (18)The choice of irrigants, including the potential use of etidronic acid, can significantly impact the adhesion and success of root canal filling materials. Further research is needed to optimize treatment protocols and enhance clinical outcomes in endodontic practice.

Conclusion:

Our study, aimed at evaluating the immediate Push Out Bond Strength (POBS) of calcium silicate-based cements (CSBC) after exposure to various root canal irrigants (RCIs) at two different setting times, suggests that NaOCl + HEBP could serve as a suitable irrigant shortly after repairing perforations with CSBC. Our findings indicate that this combination does not appear to adversely affect the bond strength of these materials. In fact, it may even provide benefits when applied 24 hours after setting. Nevertheless, further research focusing on exposure duration or exploring the composition of CSBC and RCIs could offer valuable insights for optimizing the management of these materials. A deeper understanding of how RCIs like HEBP influence CSBC performance is essential for establishing effective treatment protocols and improving clinical outcomes in perforation treatments.

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ABBREVIATIONS:

S.NO.	**ABBREVIATIONS**	**FULL FORMS**
1.	POBS	Push Out Bond Strength
2.	RCI	Root Canal Irrigants
3.	CSBS	Calcium Silicate Based Sealers
4.	EDTA	Ethylenediaminetetraacetic acid
5.	HEBP	Etidronic Acid
6.	BD	Biodentine
7.	MTA	Mineral Trioxide Aggregate