International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 • Website: www.ijfmr.com • Email: editor@ijfmr.com

Comparative Evaluation of the Effect of Sodium hypochlorite and Chlorhexidine on the Pushout Bond Strength of MTA Putty and Biodentine: An in Vitro Study

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Abstract
This in vitro investigation assessed the impact of 2.5% sodium hypochlorite and 2% chlorhexidine on the interfacial strength of Putty MTA (Safeendo) , Biodentine (Septodont) in root perforation repair. Twenty human dentin discs, sectioned to 2 mm thickness with 1.5 mm perforations, were contaminated with blood and restored with either MTA Putty or Biodentine and were allowed to set for 4–5 hours. Samples were allocated to four groups (n=5 each): Group A (MTA Putty + NaOCl), Group B (MTA Putty + CHX), Group C (Biodentine + NaOCl), and Group D (Biodentine + CHX). Each received 2 mL of the designated irrigant, and debond strength was tested with the help of universal tester. Group D showed the highest bond strength (23.4 ± 0.95 MPa), followed by Group C (20.78 ± 1.27 MPa), Group A (20.1 ± 0.75MPa), and Group B (18.5 ± 0.7 MPa),respectively with significant differences across groups ($p < 0.05$). Biodentine outperformed MTA Putty, and CHX enhanced bond strength in Biodentine and NaOCl in MTA Putty. These results concluded that Biodentine with CHX shows highest debond strength

Keywords: MTA Putty, Biodentine, Sodium hypochlorite, Chlorhexidine

1. INTRODUCTION

One of the most common procedural error that occur during access cavity preparation is root canal perforation.[1] Root perforations, whether iatrogenic or pathological, pose significant challenges in endodontic practice, compromising the tooth's prognosis by allowing microbial ingress and inflammation [2].
Effective management of perforations requires materials with excellent sealing ability, biocompatibility,

and resistance to dislodgement under functional stresses [3]. Mineral trioxide aggregate and Biodentine, are widely regarded as optimal choices for perforation repair due to their bioactivity and ability to form a durable seal [4,5]. MTA Putty (Safeendo), a premixed MTA formulation, offers improved handling and consistent setting properties [6], while Bio dentine (Septodont) is noted for its rapid setting time, high mechanical strength, and dentin-like tissue induction [7,8].

During perforation repair there is unavoidable contact of endodontic irrigants with root repair materials. Contact of root repair materials with these irrigants can affect the mechanical properties of root repair materials. Chlorhexidine and sodium hypochlorite are unavoidable part of canal disinfection [9]. Sodium hypochlorite (2.5%) is valued for its antimicrobial and tissue-dissolving capabilities [10], whereas CHX (2%) provides sustained antimicrobial activity through dentin substantivity [11]. However, irrigants may interact with repair materials, potentially altering their physical properties, including bond strength to dentin [12, 13]. Debond strength is used to assess the bonding of materials, reflecting their ability to withstand masticatory forces [14].

Previous studies have reported variable effects of irrigants on MTA and Biodentine. NaOCl may reduce bond strength by degrading dentin collagen [15], while CHX may enhance adhesion by preserving dentin integrity [16]. However, data on the comparative effects of NaOCl and CHX on MTA Putty and Biodentine in a blood-contaminated perforation model are scarce. The primary purpose of the study is to compare the debond strength of MTA Putty and Biodentine on exposing with 2.5% NaOCl and 2% CHX, simulating clinical conditions.

2. METHODOLOGY

2.1 Sample Preparation

Following ethical approval, 20 single-rooted, mandibular first premolar teeth which had undergone therapeutic extraction for orthodontic treatment were collected. Teeth with caries, fractures, or restorations were excluded. The teeth were cleaned ultrasonically and stored in 3% hydrogen peroxide for 24 hours to remove debris. Decoronation was done with the help of diamond disc .Apical and coronal sections were discarded. The midroot section horizontally sectioned into 2 mm thick dentin discs with the help of diamond disc. A standardized perforation (0.75mm radius) created in midroot sections using Gates-Glidden drill (no 5) (Mani, Japan).

2.2 Contamination and Restoration

To replicate clinical perforation scenarios, each dentin disc was contaminated with a drop of blood. The dentin discs were randomly divided to two groups for restoration with MTA Putty (Safeendo, India) or Biodentine (Septodont, France).

2.3 Group distribution

- **Group A**: MTA Putty + 2.5% NaOCl (n=5)
- **Group B**: MTA Putty + 2% CHX (n=5)
- **Group C**: Bio dentine + 2.5% NaOCl (n=5)
- **Group D**: Bio dentine + 2% CHX(n=5)

Figure 1: MTA Putty

Figure 2:Biodentine

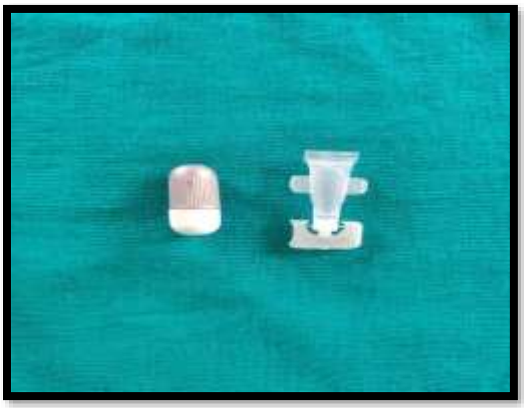


Figure 3: Sodium hypochlorite (2.5%)

Figure 4: Chlorhexidine (2%)

Each dentin disc irrigated with 2 mL of the respective irrigation solution using a 27-gauge needle, then flushing with 2 mL distilled water to remove residual irrigant. The dentin discs were air-dried for 10 seconds.

Figure 5: Mid root section

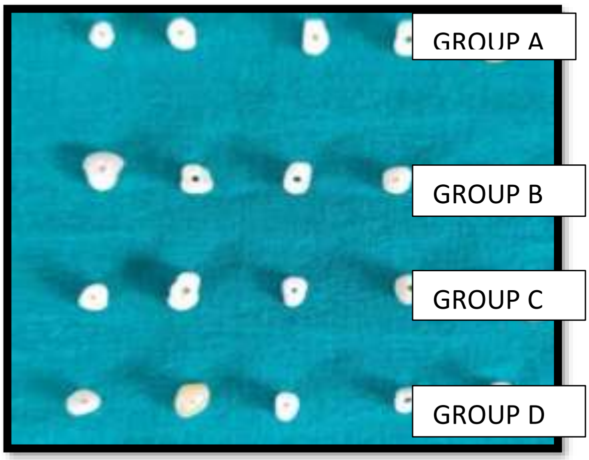


Figure 6: Restored section

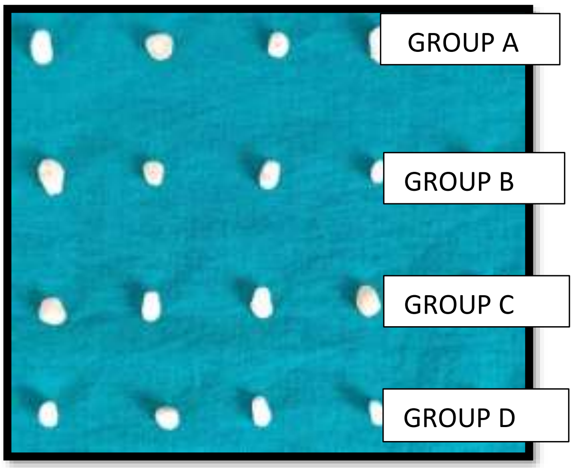


Figure 7: MTA Putty sample

Figure 8: Biodentine sample

2.4 Pushout bond strength testing

Universal tester (Instron, USA) was used to measure debond strength. Dentin discs were placed on a metal slab with a 3 mm central hole, allowing free motion of a 1.2 mm diameter plugger. The plugger aligned with perforation, and a crushing load applied at the rate of 0.5 mm/min until material dislodgement.

Figure 9: Pushout bond strength testing

2.5 Bond Strength Calculation

Pushout bond strength (MPa) Formula

$$\text{Pushout Bond Strength} = \frac{\text{Force for Dislodgement (N)}}{\text{Bonded Surface Area (mm}^2\text{)}}$$

$$\text{Bonded Surface Area} = 2 \times \pi \times r \times h = 2 \times 3.14 \times 0.75 \times 2 = 9.42\,\text{mm}^2$$

$$\text{Pushout Bond Strength (MPa)} = \frac{\text{Force (N)}}{9.42}$$

Table 1: GROUP A (MTA PUTTY +SODIUM HYPOCHLORITE)

SAMPLE	PUSHOUT BOND STRENGTH
1	20.2 MPa
2	21 MPa
3	19.8 MPa
4	19.1 MPa
5	20.7 MPa
AVERAGE	20.16 MPa

Table 2: GROUP B (MTA PUTTY + CHLORHEXIDINE)

SAMPLE	PUSHOUT BOND STRENGTH
1	18 MPa
2	17.5 MPa
3	19.1 MPa
4	19.4 MPa
5	18.5 MPa
AVERAGE	18.5 MPa

Table 3: GROUP C (BIODENTINE + SODIUM HYPOCHLORITE)

SAMPLE	PUSHOUT BOND STRENGTH
1	19.1 MPa
2	20.1MPa
3	21.2 MPa
4	22.5 MPa
5	21 MPa
AVERAGE	20.78 MPa

Table 4: GROUP D (BIODENTINE + CHLORHEXIDINE)

SAMPLE	PUSHOUT BOND STRENGTH
1	24.5 MPa

2	24.2MPa
3	23.3 MPa
4	22.8 MPa
5	22.2 MPa
AVERAGE	23.4 MPa

3. STATISTICAL ANALYSIS

Data analysed with the help of SPSS software version 26.0. One-way ANOVA compared bond strength among groups, with post hoc Tukey tests used for pairwise comparisons ($p < 0.05$).

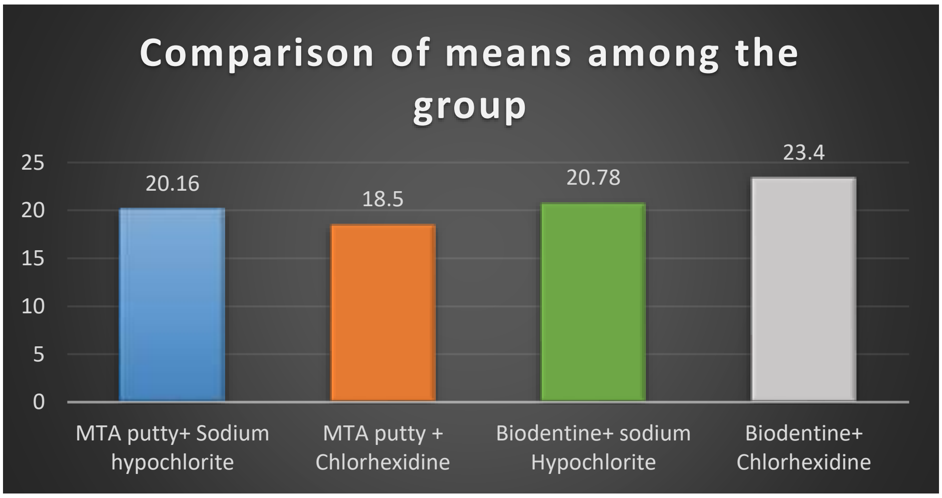
Table 5: Comparison of mean and standard deviation values of pushout bond strength (MPa) in various groups under study along with F value and P value

Group	N	Mean	Std	F-value	p-value
MTA putty+ Sodium hypochlorite	5	20.16	0.75	22.392	0.00*
MTA putty + Chlorhexidine	5	18.5	0.77		
Biodentine + sodium Hypochlorite	5	20.78	1.27		
Biodentine+ Chlorhexidine	5	23.4	0.95		

4. RESULTS

Group D (Biodentine + CHX) had the highest mean bond strength (20.16 ± 0.75 MPa), followed by Group C (18.50 ± 0.70 MPa), Group A (20.16 ± 0.75 MPa), and Group B (18.50 ± 0.70 MPa). Tukey tests confirmed significant differences between all pairs ($p < 0.05$).

Graph 1: Comparison of mean among all four groups



5. DISCUSSIONS

Biodentine's superior performance may be attributed to its tricalcium silicate composition, rapid setting (12–15 minutes), and formation of micromechanical tags within dentin tubules [17,18]. These tags enhance adhesion compared to MTA Putty, which relies on a chemical bond via calcium hydroxide formation over a longer setting period (4 hours) [19,20]. The premixed nature of MTA Putty may introduce

inconsistencies in hydration, potentially reducing bond strength [21]. Additionally, Biodentine's hydrophilic polymer enhances its adaptation to dentin. [22].
The favourable effect of CHX over NaOCl corroborates previous findings [16, 23]. NaOCl's oxidative properties degrade dentin collagen, weakening the dentin-material interface [24,25]. This degradation may disrupt the micromechanical retention of repair materials [26]. Conversely, CHX preserves collagen by inhibiting matrix metalloproteinases (MMPs), stabilizing the dentin matrix [27, 28]. CHX's substantivity allows prolonged interaction with dentin, potentially enhancing material adhesion [29, 30]. Furthermore, NaOCl may interfere with the hydration of calcium silicate cements, reducing hydroxyapatite formation [31]
CHX presence can impair setting of MTA putty and have little or no impact on biodentine. Mittag SG found that Mineral trioxide aggregate on combining with 2% Chlorhexidine set after three days. Kogan found that MTA in the presence of 2% Chlorhexidine gel shows very little setting even after one week. Nandini found out that 2 percentage Chlorhexidine reduced hardness of set Mineral trioxide aggregate .Tomer et al found that Chlorhexidine altered the morphology of Mineral trioxide aggregate with the signs of erosion.[1]
The blood contamination model is clinically relevant, as perforations often occur in the presence of blood [33]. Blood can interfere with MTA's setting, reducing bond strength by forming a porous interface [34,35]. Biodentine's faster setting and hydrophilic properties make it less susceptible to blood contamination, contributing to its higher bond strength [36, 37]. This aligns with studies reporting Biodentine's superior performance in moist environments [38].
The pushout bond strength test provides a standardized measure of adhesion [14]. The 1.5 mm perforation and 2 mm disc thickness ensured reproducibility, minimizing variables such as dentin thickness or perforation size [39]. However, the in vitro design limits extrapolation to clinical conditions, where factors like saliva, masticatory forces, and long-term degradation may influence outcomes [40]. The study tested only two irrigants, and other solutions, such as EDTA or saline, may yield different results [41,42]. Additionally, the 4–5-hour setting time may not reflect long-term material behaviour [43].. The significant differences between groups underscore the impact of irrigant-material interactions. Clinically, these findings suggest that CHX may be preferred as a final irrigant in perforation repair to maximize bond strength [46]. However, NaOCl's antimicrobial efficacy necessitates its use during canal preparation, followed by thorough rinsing to mitigate its effects on bond strength [47]. Sequential irrigation protocols (e.g., NaOCl followed by CHX) warrant further investigation [48].
Future research should explore the long-term stability of these materials under dynamic loading and hydrolytic conditions [49]. More In vivo studies are needed to reassure these findings, considering the complex oral environment [50]. Additionally, evaluating the effects of irrigant concentration, contact time, and combination protocols could optimize clinical outcomes [51].

6. CONCLUSION

This study demonstrated that Biodentine exhibits superior pushout bond strength compared to MTA Putty for root perforation repair. Irrigation with 2% CHX significantly enhances bond strength of bio dentine and reduced in case of MTA putty . Biodentine and Chlorhexidine offers highest interfacial strength, suggesting its potential as an optimal protocol. Clinicians should consider CHX as a final irrigant and prefer Biodentine for perforation repairs requiring robust adhesion. More in vivo are needed to reassure these findings.

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