

An *in vitro* Evaluation of the Push-out Bond Strength of Biodentine and MTA Plus Root Perforation Repair Materials after Irrigation with Different Endodontic Irrigants

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ABSTRACT

Aims: The aim of this study was to evaluate the push-out bond strength of Biodentine and MTA Plus root perforation repair materials after irrigation with different endodontic irrigants.

Materials and methods: Forty freshly extracted single-rooted maxillary canines were collected. The teeth were decoronated at the cemento-enamel junction using a water-cooled low-speed diamond disc. Midroot dentin was sectioned horizontally into slices by using a water-cooled low-speed diamond disk. The space of the canal was enlarged with a diamond bur. The root sections were randomly divided into two groups – Group I: Biodentine; Group II: MTA Plus. Then the samples were wrapped in a wet gauze and placed in an incubator. Immediately after incubation, the samples were divided into three subgroups to be immersed into irrigating solutions – Group I: NaOCl; Group II: saline; Group III: CHX. The push-out bond strength values were measured by using a universal testing machine. The nature of bond failure was assessed under a stereomicroscope. One specimen from each group was randomly chosen for scanning electron microscopic examination.

Results: Biodentine showed significantly higher push-out bond strength than MTA Plus.

Conclusion: Biodentine showed considerable performance as a perforation repair material even after being exposed to various endodontic irrigants, whereas MTA Plus had the lowest push-out bond strength to root dentin.

Keywords: Biodentine, MTA plus, Push out bond strength.

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INTRODUCTION

A successful endodontic therapy depends on thorough chemomechanical preparation of the root canal system as well as three-dimensional obturation that provides complete sealing of the spaces previously occupied by the canal contents.¹ Procedural accidents like perforation that occur during endodontic treatment can affect the long-term prognosis of the tooth. Root perforation is an artificial communication between the root canal system and the supporting tissues of a tooth or the oral cavity.² Perforations in endodontics can occur during:

- Access preparation
- Canal location and identification
- Root canal instrumentation
- Post space preparation.

The perforation normally occurs in the cervical area of the tooth in anterior teeth, or in the furcation area of posterior teeth, as a result of the length of the bur being used.³

To minimize the contamination of perforation area, it is important to provide an adequate seal immediately.⁴ Clinically, the operator should immediately repair the furcation perforations with an endodontic material in order to minimize the bacterial contamination and the irritation of periodontal tissue because of the usage of endodontic irrigants.⁵

Perforation repair materials seal the dentin by chemically bonding to it or by simple mechanical retention. Various materials have been used to repair perforation, such as amalgam, IRM, MTA, MTA Plus, bioceramic, and Biodentine.⁶ In this study we have used MTA Plus and Biodentine. There are some criteria suggested for the ideal repairing material. An ideal perforation repair material should provide a tight seal between the oral environment and the periradicular tissues.⁷

MATERIALS AND METHODS

For this study, 40 freshly extracted single-rooted maxillary canines were collected. The criteria for selecting these teeth were:

- Inclusion criteria:
 - Human permanent anterior teeth with single root canal
 - Completely formed apices
 - Not previously subjected to endodontic and restorative therapy

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- Exclusion criteria:
 - Visible cracks
 - Dental caries
 - Developmental anomalies.

All the teeth were cleaned in hydrogen peroxide to remove remaining debris and tissue tags and then stored in saline solution.

The teeth were decoronated at the cementoenamel junction using a water-cooled low-speed diamond disk. Midroot dentin was sectioned horizontally into slices by using a water-cooled low-speed diamond disk.

The space of the canal was enlarged with a diamond bur. The root sections were randomly divided into two groups. In group 1, Biodentine liquid from a single-dose container was emptied into a powder-containing capsule and mixed for 30 seconds at 4000 to 4200 rpm. In group 2, MTA Plus was used.

Then the samples were wrapped in a wet gauze, placed in an incubator, and allowed to set for 10 minutes at 37°C with 100% humidity. Immediately after incubation, the samples were divided into three subgroups to be immersed into irrigating solutions. In group 1, 2.5% NaOCl, in group 2, 2% CHX, and in group 3, saline solution.

After 30 minutes of immersion, all samples were removed from the test solutions, rinsed with distilled water, and allowed to set for 48 hours at 37°C with 100% humidity in an incubator.

The push-out bond strength values were measured by using a universal testing machine. The samples were placed on a metal slab with a central hole to allow free motion of the plunger. Compressive load was applied by exerting a download pressure on the surface of the test material in each sample with the Instron probe moving at a constant speed of 1 mm/min. The nature of bond failure was assessed under a stereomicroscope. One specimen from each group was randomly chosen for scanning electron microscopic (SEM) examination.

RESULTS

Push-out Bond Strength

Almost all Biodentine samples showed cohesive type of failure because of its smaller particle size and uniform

Table 1: Particle size of MTA plus with dentin

Sl. No.	Group	Number of observations	Mean±SD	Failure mode % A/C/M
1	Biodentine	20	5.82±0.7328	2.9/89.3/7
4	MTA Plus	20	5.798±0.8472	0/97/1

components. Cohesive type of failure was observed in almost all MTA Plus samples. The manufacturer of MTA Plus claimed a finer particle size that provides a better interlocking of MTA Plus with the dentin (Table 1).

Biodentine showed the highest push-out bond strength. The highest push-out bond strength was in the saline subgroup, and the lowest push-out bond strength was in the control subgroup of Biodentine. In MTA Plus, the push-out bond strength was the highest in the saline subgroup and the lowest in CHX (Table 2).

SEM ANALYSIS

The Biodentine control group showed large irregular and hexagonal crystals (Figs 1A to H). The NaOCl solution-treated Biodentine surface showed little surface crystalline formation. The crystals morphed into an undeveloped hexagonal structure with a marked decrease in size and an increase in number when compared with the control group. The saline-treated Biodentine group showed a relatively smooth surface, which consisted of small and globular crystals. The crystallized structure, which formed after exposure to CHX solution presented a typical cluster of globular crystalline with its round and prickly-shaped structure.

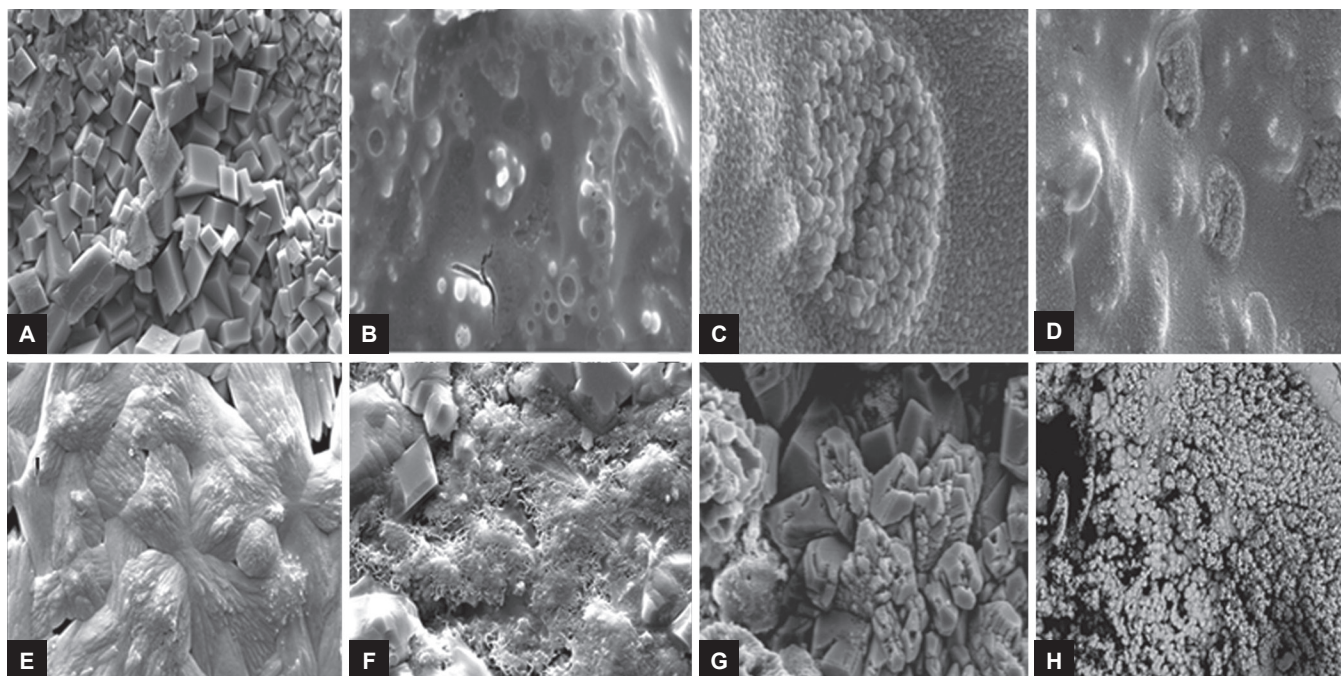
The MTA Plus saline group showed granular and semi-hexagonal crystals. The MTA Plus CHX group showed a globular structure. The MTA Plus NaOCl group showed an undeveloped hexagonal structure. The MTA Plus control group showed a small globular structure.

DISCUSSION

Root perforation is a communication between the root canal system and the periodontal ligament through the floor of the pulp chamber or the root canal wall. Accidental root perforation may also complicate the

Table 2: Push-out bond strength in biodentine and MTA plus

Group	Subgroup	1st	2nd	3rd	4th	5th	Mean	SD
Biodentine	NaOCl	5.06	5.32	6.04	5.99	7.24	5.93	0.84569498
	CHX	6.04	7.32	5.23	5.88	4.89	5.872	0.935612099
	Saline	5.83	7.22	5.67	5.92	5.55	6.038	0.675995562
	Control	5.02	6.14	5.68	4.99	5.32	5.43	0.484871117
MTA Plus (MP)	NaOCl	5.86	7.32	6.22	5.67	4.96	6.006	0.866129321
	CHX	4.97	5.87	5.45	3.95	4.86	5.02	0.721179589
	Saline	6.08	6.67	7.12	5.68	5.54	6.218	0.66822152
	Control	5.02	6.13	5.44	6.03	7.12	5.948	0.7957198



Figs 1A to H: SEM pictures of Biodentine and MTA Plus samples (10,000 \times): (A) Large irregular and hexagonal crystals of the Biodentine control group, (B) an undeveloped hexagonal crystal structure was seen after NaOCl treatment when compared with the control group, (C) small and globular crystals without the hexagonal plates in the Biodentine saline group, (D) a typical cluster of globular crystalline with its round and prickly-shaped structure in the Biodentine CHX group, (E) globular structures observed in the MTA Plus control group, (F) the MTA Plus NaOCl group showed little surface crystalline formation with a marked decrease in size when compared with the MTA Plus control group, (G) the MTA Plus saline group showed larger crystals, and (H) CHX changed the surface morphology of MTA Plus; there were fewer globular structures and they were smaller in size and less in amount

endodontic treatment per se, for example, during efforts to negotiate calcified and curved canals as well as following lateral extension of the canal preparation to a so-called strip perforation.⁸

Classification of Root Perforations

According to Fuss and Trope (1996), perforations are classified as follows:

- Fresh perforation—treated immediately or shortly after occurrence under aseptic conditions, good prognosis.
- Old perforation—previously not treated with likely bacterial infection, questionable prognosis.
- Small perforation (smaller than #20 endodontic instrument)—mechanical damage to tissue is minimal with easy sealing opportunity, good prognosis.
- Large perforation—done during post-preparation, with significant tissue damage and obvious difficulty in providing an adequate seal, salivary contamination, or coronal leakage along temporary restoration, questionable prognosis.
- Coronal perforation—coronal to the level of crestal bone and epithelial attachment with minimal damage to the supporting tissues and easy access, good prognosis.
- Crestal perforation—at the level of the epithelial attachment into the crestal bone, questionable prognosis.

- Apical perforation—apical to the crestal bone and the epithelial attachment, good prognosis.⁹

When an iatrogenic or a pathological perforation exists, this communication must be removed by a hermetic and biocompatible filling.¹⁰ In order to prevent dislodgement from the repair site, a perforation repair material should have sufficient amount of push-out bond strength with dentinal walls.¹¹

In the present study, Biodentine and MTA Plus were used as root perforation repair materials. Biodentine showed more push-out bond strength than MTA Plus. Biodentine is a CSM-based material that has a polycarboxylate-based hydrosoluble polymer system described as water-reducing agent, along with CaCl_2 as the setting accelerator.¹² The combined effect reduces the setting time and increases the compressive strength.¹³

Biodentine showed considerable performance as a repair material after being exposed to various endodontic irrigation solutions, such as CHX, NaOCl, and saline.¹⁴ MTA Plus was more resistant to dislodgement forces in the present study. MTA Plus has fine particle size, which improves its handling characteristics and may increase the speed of hydration process.¹⁵

According to De-Deus G et al, the dislodge resistance of MTA Plus was higher than MTA, which could be

attributed to its comparatively short setting time than ProRoot MTA.¹⁶ The strength of MTA Plus did not vary when exposed to various irrigating solutions.¹⁷

Because perforation repair materials are in contact with periradicular tissues, biocompatibility is one of the other essential factors when choosing a repair material.¹⁸

MTA Plus showed lowest push-out bond strength than other groups in the present study. The strength of MTA Plus varied when exposed to CHX solution.¹⁹

Mittag SG found that MTA Plus mixed with 2% CHX did set after 72 hours.²⁰ In another study, Kogan found that MTA Plus mixed with 2% CHX gel did not set even after 7 days. It seems that CHX interferes with the setting of MTA Plus.²¹

In another study, Nandini et al showed that 2% CHX reduced the surface hardness of set MTA Plus significantly after 24 hours and suggested that CHX irrigation within 24 hours of placement of MTA Plus should be avoided. Saline-treated MTA Plus samples resisted dislodgement more efficiently than the MTA Plus control group. NaOCl might have an effect on the higher push-out bond strength values of MTA Plus. Kogan et al²² reported that MTA Plus mixed with NaOCl gel could be recommended for single visit procedures because it improved the working properties and decreased the setting time of the material.

According to our SEM examinations, CHX altered the surface morphology of MTA Plus with the signs of erosion. The amount and size of globular structures on the MTA Plus surface were decreased after 30 minutes of CHX immersion.

The different failure types of Biodentine and MTA Plus were observed, which may be explained by the particle size of these materials. This affects the penetration of cement into dentinal tubules.

The modes of failure were classified into three categories as follows:

1. Adhesive failure that occurred at the filling material and dentin interface
2. Cohesive failure that happened within the filling material
3. Mixed failure mode.²³

Almost all Biodentine samples showed the cohesive type of failure because of its smaller particle size and uniform components. Formation of a "mineral tag" has also been demonstrated in Biodentine–Dentin interfaces (Han L, et al).²⁴

Cohesive type of failure was observed in almost all MTA Plus samples. The manufacturer of MTA Plus claimed a finer particle size that provides a better interlocking of MTA Plus with the Dentin.²⁵ The MTA Plus was finer than ProRoot MTA but had a similar chemical composition.

Biodentine was more resistant to dislodgement forces than MTA Plus in the present study. This is due to the biomineralization ability of Biodentine.

CONCLUSION

In this study, Biodentine proved to be a very biocompatible material and showed higher push-out bond strength as compared to MTA Plus. Push-out bond strength of Biodentine did not vary when exposed to various endodontic irrigants. Push-out bond strength of MTA Plus decreased when exposed to CHX solution and increased when exposed to saline solution. Care should be taken to prevent the contact of CHX solution with MTA Plus in single-visit endodontic therapy.

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