10.5005/jp-journals-10051-0117

ORIGINAL RESEARCH

# Evaluation of the Push-out Bond Strength of Mineral Trioxide Aggregate Mixed with Silver Zeolite: An *in vitro* Study

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## ABSTRACT

**Aim:** This study was aimed to evaluate and compare the push-out bond strengths of mineral trioxide aggregate (MTA) alone and MTA mixed with silver zeolite (SZ).

**Materials and methods:** Totally, 30 single-rooted human teeth were taken and decorinated at cementoenamel junction (CEJ). Middle third of root was sectioned to obtain 2-mm thick root section. Acrylic was adapted to the section to obtain disks of 5 mm diameter and 2 mm thickness. Canal was prepared by GG Drill no. 5 to obtain a 1.3 mm internal diameter. Sections were immersed in 17% ethylenediaminetetraacetic acid (EDTA) for 3 minutes and then in 3% sodium hypochlorite for 3 minutes and finally washed with distilled water and dried. The MTA without (group I) or with SZ (group II) was mixed with spatula on mixing pad according to manufacturer's instruction. The cement mixture was compacted with plugger into the canal. It was kept in an incubator at 37°C for 72 hours. Samples were subjected to push-out bond strength using universal testing machine.

**Results:** Statistical analysis was done using Mann–Whitney *U*-test. Statistical difference was found between groups I and II, thus showing that SZ increases the push-out bond strength of MTA.

**Conclusion:** Within the limitation of the study, addition of SZ increases bond strength of MTA.


**Keywords:** Mineral trioxide aggregate, Push-out bond strength, Silver zeolite.

**How to cite this article:** Uppal M, Arora G. Evaluation of the Push-out Bond Strength of Mineral Trioxide Aggregate Mixed with Silver Zeolite: An *in vitro* Study. Int J Oral Care Res 2017;5(4):286-289.

**Source of support:** Nil

**Conflict of interest:** None

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## INTRODUCTION

Marginal adaptation and bond strength of root-end filling materials are among crucial factors for endodontic success, because most endodontic failures arise from leakage of irritants into the periapical tissues. An ideal root-end filling material should have good sealing ability, biocompatibility, and antibacterial properties.[1-4]

Mineral trioxide aggregate has been widely used as a promising biomaterial for perforation repair and root-end filling material because of its biocompatibility and good sealing ability. Bond strength of MTA increases with time from 72 hours to 21 days. The MTA-Angelus is composed of calcium carbonate, calcium silicate, calcium aluminate, and barium zinc phosphate than conventional MTA, which contributes to improved setting time and workability.[5,6] However, MTA has low bond strength and so SZ was added to MTA to increase the same.

The SZ is known to possess antibacterial properties. Recent studies have shown that the association of MTA with SZ increases its antibacterial properties.[7-11] However, for success of endodontic procedure, it is equally important to investigate whether addition of SZ affects marginal adaptation of the cement with dentin.

There are several methods for evaluating the adhesion of dental material to dentin. These are the tensile, shear, and push-out strength tests.[12-15] The push-out test is based on shear stresses, which occur in clinical conditions and can be imitated by this test method.[16] As the push-out test generates parallel fractures in the interfacial area of the dentin bonding, it presents a better method to evaluate bond strength than conventional tests.[17]

## MATERIALS AND METHODS

### Preparation of Samples

Thirty single-rooted human teeth were taken and decorinated at the CEJ (Figs 1 and 2). Middle-thirds of root were sectioned with diamond disk to obtain 2-mm-thick root section (Figs 3 and 4). Acrylic was adapted to the section to obtain disks of 5 mm diameter and 2 mm thickness. Canal was prepared by three passes of GG Drill no. 5 to obtain a 1.3-mm internal diameter (Fig. 5). Sections were immersed in 17% EDTA for 3 minutes and then in 3%


**Fig. 1:** Armamentarium (MTA, silver zeolite, GG drill, metal jig, MicroMotor handpiece, synthetic tissue fluid, metal slab)

**Fig. 2:** Single rooted teeth decorinated at CEJ

**Fig. 3:** Sectioning tooth using diamond disc

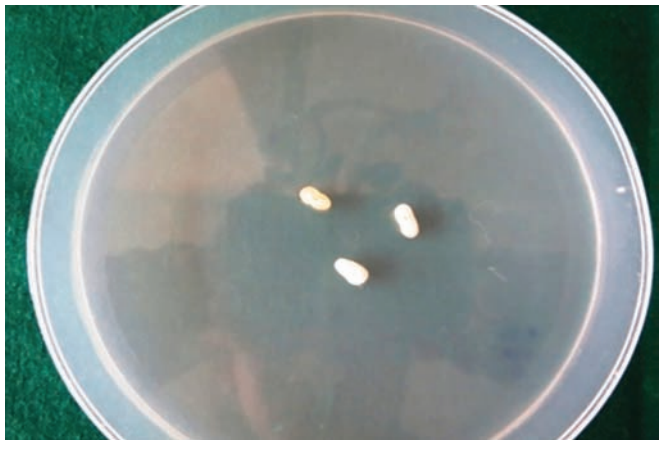

**Fig. 4:** 2 mm thick root sections

**Fig. 5:** GG drill used to prepare canal

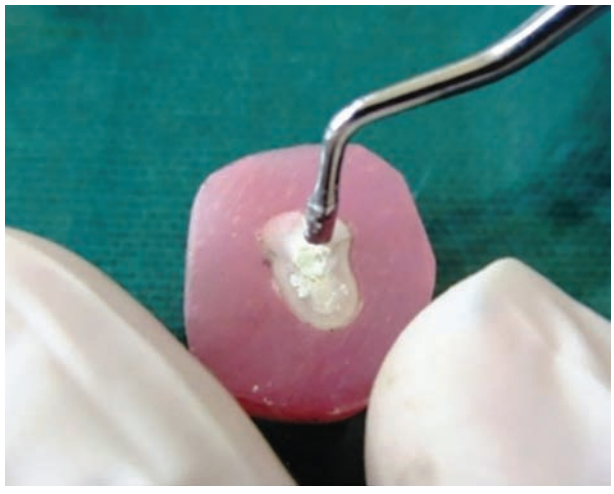

**Fig. 6:** Cement mixture compacted with plugger into canal

sodium hypochlorite for 3 minutes and finally washed with distilled water and dried.

## Division of Samples

Samples were divided into two groups of 15 each (n = 15):

- *Group I:* MTA (Angelus, Londrina, Brazil).
- *Group II:* MTA + SZ (2% mass fraction added to 1 gm of white MTA).

The MTA with or without SZ was mixed with spatula on mixing pad according to manufacturer's instructions. The cement mixture was compacted with plugger into canal (Fig. 6).

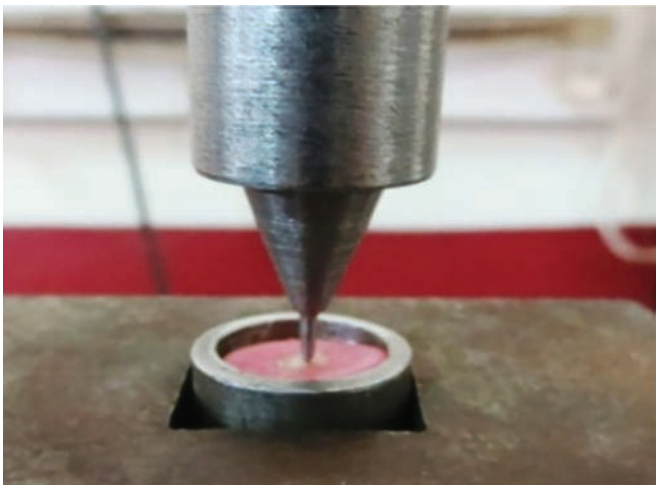

**Fig. 7:** Universal testing machine plunger at speed of 1mm/min

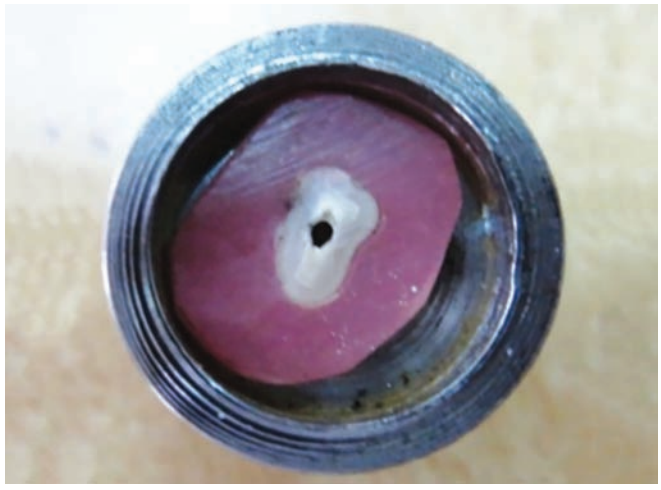

**Fig. 8:** Sample placed on metal slab

### Storage of Sample

Root slices were wrapped in pieces of gauge soaked in synthetic tissue fluid (pH 7.4). They were kept in an incubator at 37°C for 72 hours.

### Measuring of Push-out Bond Strength

Samples were subjected to push-out bond strength using universal testing machine. Samples were placed on metal slab with central hole to allow free motion of plunger (diameter of 1 mm) at the cross-head speed of 1 mm/min (Figs 7 and 8). Maximum load applied at time of dislodgment of material was recorded in Newtons. The slices were examined under stereomicroscope at ×15 magnification to determine nature of bond failure.

Statistical analysis was done using Mann–Whitney U-test.

## RESULTS

Mean push-out bond strengths for groups I and II were 11.33 and 14.19 MPa respectively (Table 1). Statistical difference was found between groups I and II, thus showing that SZ increases the push-out bond strength of MTA. Stereomicroscopic investigation revealed that among bond failures of all types of adhesives, the most prominent was with 54.33% of MTA with SZ and 57.41% of MTA.

### Statistical Analysis

Data were analyzed by Mann–Whitney U-Test

**Table 1:** Mean Push-out Bond Strength

| DESCRIPTIVE STATISTICS | | | | | | |
|---|---|---|---|---|---|---|
| | GRP | N | Minimum | Maximum | Mean | Std. Deviation |
| 1 | MPa | 15 | 9.5400 | 13.0100 | 11.332000 | 1.4653678 |
| 2 | MPa | 15 | 12.1400 | 17.3500 | 14.192000 | 1.6615191 |

## DISCUSSION

An ideal orthograde or retrograde filling material should seal to the root-end cavity wall and surrounding tissue, be able to prevent bacterial leakage from the periradicular tissues, and resist dislodging forces. The MTA possesses most of these properties, and is the "golden" standard for root-end filling[18] and used as a perforation repair material due to its sealing ability.[19] In addition, bond strength of MTA is important as normal tooth functioning can dislodge the material. Although there are various methods to evaluate the adhesion of MTA, the push-out test gives efficient and reliable results.[19] In our study, the push-out test method was used to test the bond strength of the materials.

Moistening MTA during setting is particularly important. The MTA has greater comprehensive strength when kept in a moist environment for 2 to 7 days, rather than only 4 hours. In addition, the retention characteristic and push-out strength of MTA increased with time, if kept under moist conditions. Also, as moistening of MTA at least for the first 3 days is highly important for dislodging forces,[20,21] we incubated all the samples in a moist environment for 72 hours.

In the present study, the push-out strength of white MTA was evaluated for the first time when mixed with SZ. The analysis of the mean push-out strength values of each brand revealed that there were significant differences between the groups ($p < 0.001$). In this study, the MTA with SZ group showed the highest bond strength among groups.

In this study, SZ increases the bond strength of MTA as zeolite is a microporous, aliuminoslicate material. When it is added to Portland cement, it reduces weight and helps in moderate water content, while allowing for slower drying, which improves strength. This explains the result of the differences of push-out bond strengths between MTA with and without SZ.

## CONCLUSION

Within the limitations of this study, it can be concluded that addition of SZ increases the bond strength of MTA.

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