

## Effect of pH on the compressive strength of Grey Mineral Trioxide Aggregate and Biodentine

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### Abstract:

**Aim:** The aim of this study was to compare the effect of an acidic and alkaline environment on the compressive strength of Grey Pro Root Mineral Trioxide Aggregate and Biodentine.

**Methodology:** A total of eighty human, mandibular molars were used. Perforations were made in the furcation of each molar and enlarged to #3 Pessio drills. The repair was performed, according to the materials used. Samples of each material were repaired according to the repair material and randomly divided into two groups (n=40), GMTA and Biodentine, respectively. These were further apportioned into four subgroups (n=10) according to storage media and time. Four subgroups of ten samples each were exposed to pH 5.4 and pH 7.4 for 4 days respectively. Compressive strength was measured for each of the sample and was measured 4 days after the exposure.

**Results:** Data was subjected to one-way ANOVA using Tukey's post hoc test. Biodentine displayed greater resistance to dislodgement than Grey Mineral Trioxide Aggregate at acidic environment,  $4.66 \pm 0.94$  MPa and  $2.41 \pm 0.95$ . A p-value  $< 0.05$  was considered to be statistically significant.

**Conclusion:** In an acidic environment, compressive strength of Grey Mineral Trioxide Aggregate was affected than that of Biodentine.

**Keywords:** acidic, Biodentine, compressive strength, Grey Mineral Trioxide Aggregate,

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### I. Introduction

Root canal perforation accounts for the second most common cause of endodontic failure, accounting for 9.6% of all unsuccessful cases<sup>1</sup>. Farzaneh M et al (2004) reported that retreatment success declined from a high 89% to 42% in the presence of a preoperative perforation, despite the presence of a periradicular lesion<sup>2</sup>. Perforation can occur for a number of different reasons including aberrant canal anatomy (extra canals, excessive curvature, or calcification), misguided access preparation, and overzealous instrumentation. Studies have shown that the prognosis for cervical root and chamber floor perforation is worse than other areas of the tooth because of gingival sulcus proximity<sup>3,4</sup>. Furcal perforation can lead to periradicular breakdown eventually causing loss of gingival attachment and bone, which in many cases is not reparable<sup>4,5</sup>.

The prognosis for repair is usually better when the perforation is closed immediately because of increased inflammation with time<sup>4</sup>. An intracanal approach is preferred, potentially eliminating the need for a surgical approach or intentional replantation<sup>6</sup>.

Mineral trioxide aggregate has been used for repair of root perforations, root end filling material, vital pulp therapy including direct pulp capping and pulpotomy of immature teeth with vital pulps (apexogenesis) and as an apical barrier for teeth with open apices<sup>7-10</sup> making it an extremely popular endodontic material. But the quest for better endodontic materials has led to the introduction of a tricalcium silicate based material called Biodentine, which has clinical applications similar to those of MTA<sup>11</sup>. Variations in the periapical pH can affect the physical and chemical properties of a root end filling material. The effect of acidic pH on the compressive strength of MTA has been well studied and documented<sup>12</sup>. As sufficient literature on Biodentine is lacking, the present study was designed to evaluate the surface microhardness of the material when exposed to different levels of acidic pH.

## II. Materials And Methods

### 2.1 Selection of Teeth and Specimen Preparation

Eighty human mandibular, first molars were with completely formed roots, minimal or no caries, no cracks, and no fused roots were included in the study. The selection was based on the degree of separation of the roots so as the furcal area is visible enough. Immediately after extraction the roots of each tooth was cleaned of soft tissues or bone remnants with periodontal curettes, disinfected with Sodium hypochlorite (NaOCl) 3% (Vishal) for 10 minutes and stored in normal saline solution until usage. The teeth were stored in normal saline to prevent desiccation of the teeth due to loss of moisture. Molars were amputated 3 mm apical to the furcation at a direction perpendicular to the long axis of the tooth using a water-cooled, diamond disc (Brasseler Dental Products, Savannah, USA). Similarly the crowns were also shortened to a level 3 mm coronal to the cement enamel junction using the water-cooled, diamond disc (Brasseler Dental Products, Savannah, USA). Endodontic access cavity was made in each molar, using a #4 diamond round bur (SS White, Germany), and safe-end bur (Mani, India).

Perforations were initially created using size ½-round bur on a long neck (LN Bur; Maillefer, Dentsply, Switzerland) between the canal orifices in an apical direction down to the external surface of the tooth at the furcation area. The perforation was then enlarged using Pecho drills (Mani, Tochigi-ken, Japan) from size 1 to 3, corresponding to diameter of 1.1 mm, in a direction parallel to the long axis of the tooth.

The specimens were randomly divided into 2 equal groups according to the repair material, consisting of forty teeth each (n=40): Grey Pro Root MTA and BD. The specimens in each group were further randomly divided into 4 equal subgroups, consisting of ten teeth each (n = 10) according to the storage media and time to which the repair materials were exposed as follows: subgroup A: specimens were placed for 4 days in contact with PBS at pH of 7.4, subgroup B: specimens were placed for 4 days in contact with an acidic acetic acid solution buffered to pH of 5.4. The specimens were inserted in PBS-moistened floral foam to simulate as much as possible clinical conditions. The repair procedure was performed under 14x magnification using surgical microscope (Opmi-Pico; Karl Zeiss, Jena, Germany). The materials were mixed according to the manufacturers' instructions. They were applied into the perforation in increments using the micro apical placement system (MAP; ProduitsDentaires SA, Vevey, Switzerland) and condensed using endodontic pluggers. A cotton pellet soaked with the assigned solution for each subgroup was placed in the pulp chamber over the repair material, and the specimens were inserted in the floral foam moistened with the same respective solution. The specimens were stored at 37°C and 100% relative humidity. The soaked cotton was changed every 4 days.

### 2.2 Assessment of Dislodgment Resistance

The repair materials were dislodged from perforations using a universal testing machine, Instron (Model LRX-Plus; Lloyd Instruments Ltd, Fareham, UK). The repair materials were loaded using a 1-mm-diameter, cylindrical plunger to displace it in an apical-coronal direction at a load cell of 5 kN and a crosshead speed of 0.5 mm/min until failure.

The maximal force applied to the material before dislodgment was recorded in Newton (N). The calculation of the push-out bond strength (MPa), as an indicator for dislodgment resistance, was done using the following equation:

$$\text{Push-out bond strength (MPa)} = \text{force to dislodgement (N)} / \text{adhesive surface area (mm}^2\text{)}.$$

$$\text{Adhesive surface area (mm}^2\text{)} = 2\pi r h,$$

Where, "r" is the radius of the perforation cross-section, and "h" is the height of the perforation.

## III. Results And Discussion

After 4 days there was a statistically significant difference among groups (*p value*) where Biodentine had significantly highest bond strength Dislodgment Resistance of calcium silicate based materials in various clinical situations.

**TABLE:** Mean push out bond strength of GMTA and Biodentine in acidic and alkaline environment.

Materials	Specimens placed for 4 days in contact with PBS at pH of 7.4		Specimens placed for 4 days in contact with an acetic acid solution buffered to pH of 5.4	
	MEAN	SD	MEAN	SD
Pro Root GMTA	5.06	0.60	2.41	0.95
Biodentine	8.62	2.25	4.66	0.94

**TABLE:** Multiple comparison Tukey test for 4 days in PBS at pH 7.4.

Mean push out bond strength of GMTA was 5.06 MPa, for Biodentine it was 8.62MPa.

On comparing push out bond strength in two groups, statistically significant difference was found between GMTA and Biodentine ( $p=0.009$ ).

Group		Mean Difference (I-J)	Std. Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
BD	G-MTA	3.55	0.98	0.009 S, $p<0.05$	0.93	6.17

**TABLE:**Multiple comparison Tukey test for 4 days in acetic acid at pH 5.4.

Mean push out bond strength of GMTA was 2.41MPa, for Biodentine it was 4.66MPa.

On comparing push out bond strength in two groups, statistically significant difference was found between GMTA and Biodentine ( $p=0.16$ )

Group		Mean Difference (I-J)	Std. Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
BD	GMTA	2.25	0.67	0.016,S, $p<0.05$	0.44	4.06

#### IV. Discussion

A perforation repair material is invariably placed in an environment where inflammation is present and where the pH is likely to be acidic<sup>12,13</sup>. This acidic pH is likely to be an impediment to the setting reaction of Biodentine causing it to affect the compressive strength of the set material.

Namazikhahet al<sup>14</sup> stated that at an alkaline pH of 7.4 the Vickers microhardness of MTA was 53.19 which reduced radically as the pH was lowered.

Storm B et al<sup>15</sup> compared the hygroscopic linear setting expansions of GMTA, WMTA, and PC with a new device. He reported that GMTA expanded significantly more than WMTA in either water or HBSS immersion. GMTA had a decrease in expansion that nearly reached significance. The small sample size may have reduced the ability to confirm this difference. HBSS contains sodium hydrogen phosphate ( $\text{HNA}_2\text{O}_4\text{P}$ ). Phosphate buffering could possibly affect setting expansion or the iron-containing component could have been more or less reactive in a phosphate environment. The higher level of tetracalcium aluminoferrite in GMTA reacts differently in HBSS than in water, it probably explaining the reduction in expansion observed only in GMTA.

The present study was designed to compare the compressive strength of Biodentine with Grey Mineral Trioxide Aggregate (GMTA). The mean compressive strength of Biodentine in alkaline environment was  $8.62 \pm 2.25$  MPa, whereas in acidic environment its compressive strength was  $4.66 \pm 0.94$  MPa; whereas, the mean compressive strength of Grey Mineral Trioxide Aggregate (GMTA) in alkaline environment was  $5.06 \pm 0.60$  MPa and in acidic environment was  $2.41 \pm 0.95$  MPa.

The above results indicate; that the compressive strength of a calcium silicate based material reduced from alkaline environment to acidic environment indicating that an acidic environment alters the physicochemical properties.

Biodentine, significantly ( $p<0.05$ ) shows higher values of compressive strength in acidic as well as in alkaline environment in comparison with GMTA.

Poplai et al also stated that surface hardness of Biodentine was impaired in the presence of acidic environment<sup>16</sup>.

Higher values of microhardness of Biodentine can be explained on the basis of calcium chloride present in the liquid provided by the manufacturer. The addition of  $\text{CaCl}_2$  is intended to reduce the setting time of the Portland cement and to improve its physicochemical properties in civil construction<sup>16</sup>.

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