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ORIGINAL RESEARCH

Effect of Acidic Environment on the Push-out Bond Strength of Biodentine™

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ABSTRACT

Introduction: An apical sealing material may be exposed to an inflamed environment with low pH levels. The change in physical and chemical properties of mineral trioxide aggregate has been well-documented in the presence of low pH. However, on literature search there is no documentation of the effect of low pH on Biodentine™.

Aim: To compare the effects of various levels of acidic pH on the push-out bond strength of Biodentine™.

Materials and methods: Forty root dentin slices from single rooted human teeth were sectioned horizontally. The canal lumens were instrumented to obtain a standardized diameter of 1.3 mm and filled with Biodentine™. The specimens were then randomly divided into four groups (n = 10) and wrapped in pieces of gauze soaked in phosphate buffer saline solution (pH = 7.4) and butyric acid buffered at pH values of 4.4, 5.4 and 6.4 respectively. They were incubated at 37°C for 4 days. Push-out test were then carried out using universal testing machine. The data was analyzed using one-way analysis of variance (ANOVA) technique with Tukey's correction for multiple group comparisons.

Results: Data was subjected to one-way ANOVA using Tukey's post hoc test. Group I (control, pH = 7.4) showed greatest bond strength of 19.5 ± 0.9 MPa. The least push-out bond strength of 11.7 ± 0.5 MPa was observed in Group IV where the specimens were soaked at pH 4.4. A p-value less than 0.05 were considered to be statistically significant.

Conclusion: The force needed to displace Biodentine was significantly lower in samples stored at lower pH values.

Keywords: Biodentine, Mineral trioxide aggregate, Pulp and periapical lesion.

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INTRODUCTION

Overtime, there has been a continuous search for dental materials that present an ideal combination of good mechanical, physicochemical and biological properties. This search is even more incessant where treatment of periapical lesions is concerned. An ideal root-end filling material has to be biocompatible, dimensionally stable, adhere to the dentinal walls with excellent marginal adaptation preventing the passage of bacteria, and be unaffected in the presence of tissue fluids that may be acidic in an infected area.[1-4] Mineral trioxide aggregate (MTA) has most of these essential properties and is highly popular as a root-end filling material.[5] Recently a new tricalcium silicate-based material has been introduced, known as Biodentine, the applications of which are similar to those of MTA.[6]

Variations in pH of periapical tissues may affect the physical and chemical properties of the material. The push-out test can be used to measure the interfacial shear strength developed between different surfaces, providing additional information on the evaluation of adhesion properties.[7,8] The effect of acidic pH on the push-out bond strength has been well-documented for MTA but there is lack of information about Biodentine in a similar environment.[9]

AIM

To evaluate the push-out bond strength between Biodentine and intraradicular dentin after exposure to a range of acidic pH.

MATERIALS AND METHODS

Forty freshly extracted single rooted human anterior teeth which were intact and noncarious were used for the study. The teeth were stored in chloramine-T at 4°C for up to 1 month before use. Mid-root dentin was sectioned horizontally, perpendicular to the long axis of the teeth into 1.00 ± 0.05 mm thick slices using a microtome. The lumen of each slice was instrumented with Gates-Glidden drills (Dentsply-Maillefer, Ballaigues, Switzerland) size #1 through #5 to obtain 1.3 mm standardized cavities. Biodentine was mixed according to manufacturer's instructions in an amalgamator and placed in the cavities using a carrier (Premier Dental, PA, USA) and condensed thoroughly with a plugger (Dentsply-Maillefer, Ballaigues, Switzerland) followed by additional material until a surplus was seen above the cavity margins. The material in each sample was then burnished with a burnisher (Analylic, SybronEndo, Orange, CA, USA). The specimens were then randomly divided into four groups (n = 10). In Group I, the specimens were wrapped in phosphate buffered saline solution (pH = 7.4). In Groups II, III and IV the specimens were wrapped in pieces of gauze soaked in butyric acid buffered at pH values of 6.4, 5.4 and 4.4 respectively. Each group was placed in a separate vial. Acid soaked pieces of gauze were replaced everyday with fresh ones to ensure sufficient acidic environment within the vials. The specimens were then incubated for 4 days at 37°C.

The push-out bond strengths were measured using a universal testing machine with a crosshead speed of 5 mm/min. The samples were placed on a metal slab with a central hole to allow the free motion of the plunger. The compressive load was applied by exerting a downward pressure on the surface of the material using a 1 mm diameter cylindrical plunger. The plunger had a clearance of approximately 0.2 mm from the margin of the dentinal wall to insure contact with the material only. The maximum load applied to the material in the sample at the time of dislodgment was recorded in Newtons. In order to express the bond strength in megapascals (MPa) the recorded value was divided by the adhesion area of the root canal filling. The adhesion area was calculated by the following formula: $2\pi r \times h$ where 'r' is the root canal radius and 'h' is the thickness of the root dentin slice in millimeters.

RESULTS

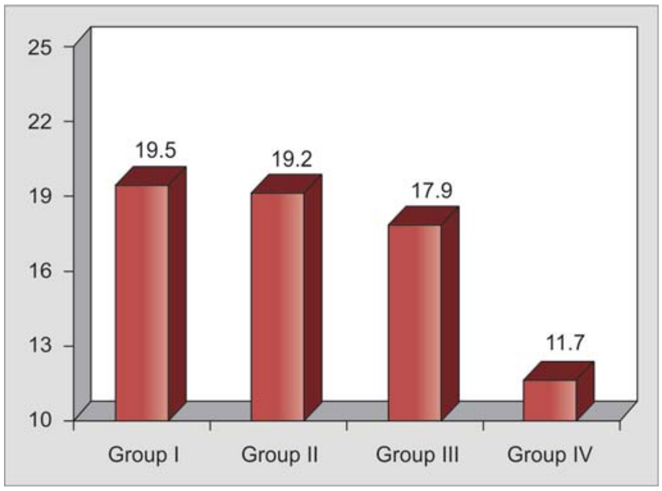
The data obtained after the push-out test was performed is tabulated in Table 1. The mean retentive strength of the test groups are shown in Graph 1 and the statistical comparison of groups are shown in Table 2. One-way analysis of variance (ANOVA) using Tukey's post hoc correction for multiple group comparisons showed significant difference between bond strengths of all the groups except for between Group I (control, pH = 7.4) which showed bond strength of 19.5 ± 0.9 MPa and Group II (pH = 6.4) which showed bond strength of 19.2 ± 0.8 MPa where the p-value was 0.846. A p-value less than 0.05 was considered to be statistically significant. Group III (pH = 5.4) showed bond strength of 17.9 ± 1.1 MPa. The least push-out bond strength was observed in Group IV (11.7 ± 0.5 MPa) where the specimens were soaked at pH = 4.4.

DISCUSSION

There are various methods for evaluating the adhesion of a dental material to dentin including tensile, shear and push-out strength tests. In our study, the push-out test method was used to test the bond strength between Biodentine and dentin while exposed to acidic solutions with several pH values since inflamed and/or infected tissues have a low pH.[10,11] Biodentine being a root end filling material will be exposed to this sort of an acidic environment. Butyric acid has been used in the present study since its presence has been reported in inflamed tissue by gas chromatography and is an indicator of anaerobic infection.[12]

Table 1: Bond strength in megapascals (MPa) of all sample tested

Sample ID	*Group I (control pH = 7.4)*	*Group II (pH 6.4)*	*Group III (pH 5.4)*	*Group IV (pH 4.4)*
1	20.63	18.98	17.98	11.37
2	18.87	19.42	16.42	11.97
3	19.68	19.20	18.54	11.82
4	19.55	20.38	19.44	12.32
5	18.42	19.75	16.98	11.49
6	20.02	19.54	16.67	12.22
7	18.92	18.49	18.33	10.98
8	18.04	19.88	16.78	12.09
9	20.23	18.13	18.43	10.84
10	20.41	17.89	19.32	11.75



Graph 1: Mean retentive strength

Table 2: Statistical comparison of groups

Group comparison	*Bond strength*
Group I *vs* group II	0.846
Group I *vs* group III	0.001 (significant)
Group I *vs* group IV	0.001 (significant)
Group II *vs* group III	0.010 (significant)
Group II *vs* group IV	0.001 (significant)
Group III *vs* group IV	0.001 (significant)

Shokouhinejad el al studied the effect of acidic environment on MTA where the force needed for displacement of MTA was significantly lower as the pH values decreased. In that study the greatest mean push-out strength of 7.28 ± 2.28 MPa was observed at pH 7.4 and the value decreased to 2.47 ± 0.61 MPa at pH 4.4.[9]

The mean push-out bond strength at pH 7.4 was 19.5 ± 0.9 MPa and even at pH 4.4 the bond strength obtained was 11.7 ± 0.5 MPa. Higher bond strength of Biodentine can be explained on the basis of calcium chloride ($CaCl_2$) present in the liquid provided by the manufacturer. The addition of $CaCl_2$ is intended to reduce the setting time of the Portland cement and to improve its physicochemical properties in civil construction.[13,14]

A possible explanation behind $CaCl_2$ enhancing the physical properties are that $CaCl_2$ penetrates the pores of cements, strongly accelerating the hydration of silicates and leading to their faster crystallization and reducing the setting time.[15,16]

It may also alter the chemical composition, surface area and characteristics of the pores of cements, providing the advantages of increased resistance to compression and reduced permeability.[15]

CONCLUSION

Under the conditions of this study it could be concluded that the bond strength of Biodentine was impaired in conditions of low pH values.

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