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Original Research

Bond strength of composite resin to white mineral trioxide aggregate

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ABSTRACT:

Background: To investigate how various surface treatments of MTA influence the bond strength between MTA and composite resin. **Materials & Methods:** A set of 20 acrylic blocks with cylindrical shapes, each featuring a hole, were prepared and filled with ProRoot MTA. These blocks were then categorized into four groups for subsequent examination: Group 1, which underwent no surface treatment; Group 2, subjected to phosphoric acid etching; Group 3, treated with sandblasting; and Group 4, exposed to hydrofluoric acid (HF) etching, followed by rinsing and silane application. **Results:** Significant differences in bond strength values were observed between Group 1 and Groups 3 and 4. Additionally, there were noteworthy variations in bond strength values between Group 2 and Group 3, as well as between Group 3 and Group 4. **Conclusion:** Optimal approaches for preparing the surface of MTA before composite resin bonding were determined to be either phosphoric acid etching or HF etching in conjunction with silanization.

Keywords: mineral trioxide, composite, bond strength.

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INTRODUCTION

Mineral trioxide aggregate (MTA) was introduced as a retrograde filling material by Lee et al. in 1993. [1] In the last decade, MTA has become a very popular biomaterial, especially in endodontics and pediatric dentistry field, owing to its physical and regenerative properties such as; setting in the presence of blood, saliva, or other biological fluids, low solubility after setting, providing cementum regrowth and a strong barrier for bacterial leakage; inducing mineralized tissue formation, control of bleeding also, great biocompatibility. [2,3]

Pulp capping with MTA has gained very popularity because of providing dentinogenesis in human pulp cells. [4,5] When compared with calcium hydroxide as a pulp capping agent; MTA forms faster, uniform and thicker dentinal bridge, provides less pulp inflammation and bacterial microleakage with lower solubility and better marginal adaptation. [6] However, it has disadvantages such as high cost, long setting time, difficulty in manipulation, low resistance to compression and flow capacity, discoloration of tooth structure, and release of arsenic. [7] Mineral trioxide aggregate (MTA) has been confirmed and used as an apical barrier in cases of open apices, repair of perforations, treatment of internal/external root resorption, and direct pulp capping (DPC). [8]

Provision of a coronal seal during restorative procedures of root-filled teeth, especially in cases of perforation or DPC, is very important. In such cases, the use of a secondary intracoronal seal has been suggested with the application of adhesive materials due to inadequate sealing of the perforations or exposure areas. [9]

Mineral trioxide aggregate (MTA) is a biomaterial that has been investigated for endodontic applications since the early 1990's. [10] It is hard tissue conductive, hard tissue inductive and biocompatible. [11] Over the years, research on the material has resulted in MTA being applied in various clinical situations like furcation repair, internal resorption treatment, pulpotomy procedures, capping of pulps with reversible pulpitis, apexification and obturation, in addition to its use as a suitable root-end filling material. [12] With the increased use of MTA in pulp capping, pulpotomy, perforation repair, apexification and obturation, the material that would be placed over MTA as a final restoration is an important matter. [13] Some of the final restorative materials used in endodontics are Amalgam, Glass Ionomer Cements (resin modified and metal modified Glass Ionomer Cements) and Composite resins. [14]

Resin composites and glass ionomer cements (GICs) are very popular in restorative dentistry because of their esthetic qualities. Cemal Yesilyurt et al. studied the shear bond strength of conventional glass ionomer cements bound to mineral trioxide aggregate allowed to set for 2 different times, 45 minutes and 72 hours. The results of the study showed that the shear bond strength of the conventional GICs to the MTA was similar after 45 minutes and 72 hours and the authors concluded that GICs might be used over MTA after the MTA has set for 45 minutes to allow for single-visit procedures. [15] Hence, this study was conducted to investigate how various surface treatments of MTA influence the bond strength between MTA and composite resin.

Materials & Methods:

A set of 20 acrylic blocks with cylindrical shapes, each featuring a hole, were prepared and filled with ProRoot MTA. These blocks were then categorized into four groups for subsequent examination: Group 1, which underwent no surface treatment; Group 2, subjected to phosphoric acid etching; Group 3, treated with sandblasting; and Group 4, exposed to hydrofluoric acid (HF) etching, followed by rinsing and silane application. To maintain uniformity, OptiBond Solo Plus adhesive was applied across all groups. Subsequently, composite resin cylinders were affixed to the surfaces of the samples. Statistical analysis was conducted using the Kruskal–Wallis test and Mann-Whitney tests, and the results were assessed using SPSS software.

Results:

The Kruskal-Wallis test identified a statistically significant difference in microshear bond strength values among the four study groups ($P < 0.05$). Notably, Group 4, which underwent HF etching and silane application, displayed the highest microshear bond strength (29.7), whereas Group 3, subjected to sandblasting, exhibited the lowest value (7.0). Significant differences in bond strength values were observed between Group 1 and Groups 3 and 4. Additionally, there were noteworthy variations in bond strength values between Group 2 and Group 3, as well as between Group 3 and Group 4.

Table 1: mean values and 95% confidence intervals of microshear bond strength

Study groups	Mean	95% CI for mean	
		Lower bound	Upper bound
No treatment	18.28	8.04	21.52
Phosphoric acid	25.20	17.54	27.14
Sandblasting	7.04	2.89	8.46
Hydrofluoric acid	29.75	16.47	34.15

Discussion:

Furthermore, in most cases with furca perforations or DPC, it is not possible to achieve retention from the intracanal post or secondary retention features. As a result, the advantages of applying an adhesive restoration over MTA consist of achieving secondary retention and secondary seal. In many cases, composite resin is recommended because it exerts lower forces on the pulp capping biomaterial during placement of the final restoration. [16] Hence, this study was conducted to investigate how various surface treatments of MTA influence the bond strength between MTA and composite resin.

In the present study, the Kruskal-Wallis test identified a statistically significant difference in microshear bond strength values among the four study groups ($P < 0.05$). Notably, Group 4, which underwent HF etching and silane application, displayed the highest microshear bond strength (29.7), whereas Group 3, subjected to sandblasting, exhibited the lowest value (7.0). A study by Samimi P et al, compared the effect of different surface treatments of mineral trioxide aggregate (MTA) on the bond strength of composite resin to MTA. Forty cylindrical acrylic blocks with a hole were prepared and filled by ProRoot MTA. The samples were assigned to four groups: Group 1 – no surface treatment; Group 2 – phosphoric acid etching; Group 3 – sandblasting; and Group 4 – hydrofluoric acid (HF) etching, rinsing, and silane application. OptiBond Solo Plus adhesive was utilized in all the groups. Then, composite resin cylinders were bonded to sample surfaces. The samples were thermocycled and tested for microshear bond strength using a universal testing machine at a crosshead speed of 1 mm/min. Data were analyzed with Kruskal–Wallis and Mann–Whitney tests. Scanning electron microscopy images were prepared for each study group after surface treatments. Means and standard deviations of bond strength values in study groups 1–4 were 14.83 ± 7.76, 21.85 ±7.99, 6.48 ± 3.89, and 26.01 ± 11.09 Mpa, respectively. Within the limitations of the study, phosphoric acid etching or HF etching plus silanization was preferred to surface treatment of MTA before composite resin bonding. [17]

In the present study, significant differences in bond strength values were observed between Group 1 and Groups 3 and 4. Additionally, there were noteworthy variations in bond strength values between Group 2 and Group 3, as well as between Group 3 and Group 4. Another study by Tulumbaci F et al, evaluated the SBS of composite resin (Filtek™ Z250; 3M ESPE, USA), compomer (Dyract XP; LD Caulk/Dentsply, USA), and resin-modified glass ionomer (Photac-Fil Quick Aplicap; 3M ESPE, USA) to white MTA and Biodentine. Ninety acrylic cylindrical blocks were prepared and divided into two groups (n = 45). The acrylic blocks were randomly allocated into 3 subgroups; Group-1A: MTA + composite (Filtek™ Z250), Group-1B: MTA + compomer (Dyract XP), Group-1C: MTA + RMGIC (Photac-Fil Quick Aplicap), Group-2A: Biodentine + composite, Group-2B: Biodentine + compomer, Group-2C: Biodentine + RMGIC. The specimens were mounted in Universal Testing Machine. A crosshead speed 1 mm/min was applied to each specimen using a knife-edge blade until the bond between the MTA/Biodentine and restorative material failed. Failure modes of each group were evaluated under polarized light microscope at ×40 magnification. There was no statistically significant difference between MTA + Composite resin with MTA + Compomer; and MTA + RMGIC with Biodentine + RMGIC ($P > 0.05$). There were statistically significant differences between other groups ($P < 0.05$). The results of the study displayed that although many advantages of Biodentine over MTA; MTA has shown better SBS to compomer and composite resin materials than Biodentine. [18] Neelakantan P et al, aimed to measure the bond strength of a resin-based composite to white MTA (WMTA) with different bonding strategies at different intervals. The authors bonded resin-based composite to MTA with three bonding protocols ($n = 45$ per group) (group 1, total-etching adhesive; group 2, two-step self-etching adhesive; or group 3, one-step self-etching adhesive), immediately (subgroup A), 45 minutes (subgroup B) or 24 hours (subgroup C) after placement of the MTA. In all three groups, subgroup A demonstrated greater bond strengths than the other subgroups. Group/subgroup 3/A demonstrated the highest bond strength (mean [standard deviation] 49.2 [2.1] megapascals), which was significantly higher than that in all other groups ($P < .05$). This was followed by group/subgroup 1/A (40.2 [2.5] MPa), 2/A (38.4 [1.3] MPa) and 1/B (38.5 [1.91] MPa). The lowest bond strength was shown by group/subgroup 2/C (14.7 [1.90] MPa). There was a significant difference between the two-step and one-step self-etching adhesives at all three intervals ($P < .05$). Within the limitations of the study, the representative one-step self-etching adhesive demonstrated the strongest bond to WMTA immediately after fabrication of MTA samples. [19] Atabek D et al, compared the shear bond strengths of various adhesive systems to white mineral trioxide aggregate (WMTA) with different time intervals. Two hundred cylindrical acrylic blocks with a hole (4-mm diameter and 2-mm height) were prepared. The holes were filled with WMTA, and the specimens were allocated into 5 groups. Forty specimens were stored for 4, 24, 48, 72, and 96 hours at 37°C and 100% humidity. Each group was divided into 4 subgroups: group 1, All-Bond SE (Bisco Inc, Schaumburg, IL); group 2, All-Bond 3 (Bisco Inc); group 3, One-Step Plus (Bisco Inc); and group 4, control. After the application of adhesive systems, composite resin (Aelite, Bisco) was applied over the WMTA. Shear bond strengths were measured using a universal testing machine, and the data were subjected to 1-way analysis of variance and the Scheffé post hoc test. There was a significant difference between the 4-, 24-, 48-, 72-, and 96-hour measurements in all of the adhesive systems ($P < .001$). Among all time intervals, group 3 showed significantly higher bond strengths to WMTA than the other groups ($P < .001$). Groups 1 and 2 were similar ($P = .365$). It was concluded that if a longer waiting time can be practiced after the mixing of WMTA, higher shear bond strength measurements can be obtained. Also, when WMTA was used with total-etch adhesive systems, it showed better shear bond strength. [20] A study used scanning electron microscopy to evaluate the effects of acid etching on surface characteristics of MTA and showed that the disordered structure and spindle-shaped crystals were removed during the process; [21] therefore, the selective removal of the matrix surrounding the crystals results in a sponge-like surface suitable for bonding to composite resins with no significant effect on MTA structure.

Phosphoric acid treatment eroded the crystalline structure on the white MTA surface, creating a cracked surface that contained internal pores. Consistent with the results of the present study, the characteristic etching pattern on MTA as a result of phosphoric acid treatment was reported previously, [21] suggesting that phosphoric acid might contribute to a reliable micromechanical bonding of the etch-and-rinse adhesive system to MTA. [22]

Conclusion:

Optimal approaches for preparing the surface of MTA before composite resin bonding were determined to be either phosphoric acid etching or HF etching in conjunction with silanization.

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