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Assessment of Bioactive Resin-Modified Glass Ionomer Restorative as a new CAD/CAM material

A Thesis

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Abstract

Bioactive materials have been used in almost all fields of dentistry. However, bioactive materials have not yet been implied in the field of CAD/CAM materials.

The aims of this study were to fabricate a bioactive CAD/CAM resin block from ACTIVA BioACTIVE-Restorative material and testing the fabricated block as compared with a reinforced resin block (BRILLIANT Crios) in respect to the marginal adaptation, fracture strength, shear bond strength, color stability, ion release, and bioactivity.

The bioactive resin blocks were fabricated from ACTIVA BioACTIVE-Restorative material (PULPDENT Corp., USA) using a clear rectangular Teflon mold in accordance with size C14 CAD/CAM block. Thirty-two human maxillary first premolar teeth were prepared to receive full crowns and divided into two main groups of 16 teeth each according to the type of block used to fabricate the crowns: Group A: crowns fabricated from reinforced composite block (BRILLIANT Crios, Coltene), Group B: crowns fabricated from the developed bioactive resin block. Each group was then subdivided into two subgroups according to the type of resin cement used for cementation, Subgroups (A1, B1): RelyX Ultimate adhesive resin cement, Subgroups (A2, B2): ACTIVA BioACTIVE self-adhesive resin cement. The prepared teeth were then scanned using CEREC Omnicam digital intra-oral scanner and crowns were designed using Sirona InLab software (version 15.1) and milled using InLab MC XL milling unit. The marginal gap of each crown was then measured pre- and post-cementation at four points on each tooth surface using a digital microscope at a magnification of 230x.

For fracture strength testing, the cemented crowns were subjected to compressive axial loading in computer-controlled universal testing machine

(LARYEE, China) at crosshead speed of 0.5 mm/min until fracture occurred and the maximum breaking load of each crown was recorded in Newton.

For shear bond strength testing, thirty-two human maxillary first premolar teeth were cut occlusally to the depth of the central groove to expose peripheral dentin surface. A total of 32 cylindrical-shaped specimens (5*5 mm) were milled (16 specimens from each block type), and then subdivided into two subgroups according to the type of resin cement used for cementation: Subgroups (A1, B1): RelyX Ultimate cement, Subgroups (A2, B2): ACTIVA BioACTIVE-cement. After cementation, each specimen was loaded to failure at a crosshead speed of 1.0 mm/min with knife-edge chisel rod and the shear bond strength value of each specimen was recorded in MPa.

For color stability testing, a total 48 rectangular specimens (14*12*1.2 mm) were milled (24 specimens from each block type), and then divided into three subgroups of 8 specimens each according to the staining solution used (deionized distilled water, tea and coffee). Easyshade advance 4.0 spectrophotometer was used for the assessment of color change (ΔE) before and after seven days of immersion in the different staining solutions.

Ion release study involved the measurement of fluoride, calcium, and phosphate ions. For fluoride ion release, 45 disc specimens (10*1.2 mm) were milled from each block material and immersed in 10 ml of deionized distilled water. For calcium and phosphate ions release, another 45 discs of the same dimension as for fluoride ion release were milled from each block material and immersed in 10 ml of simulated body fluid (SBF, pH=7.4). The release of the different ions into the immersion solution was measured in ppm at 1, 7, and 28-days of immersion using ion selective electrode for fluoride ion and Inductively Coupled Plasma-Optical Emissions Spectroscopy for calcium and phosphate ions. On the other hand, those discs immersed in the SBF were used for analysis of bioactivity with XRD, FTIR, and SEM with EDX at the forementioned three different time periods.

The results of these studies were subjected to statistical analysis including one-way ANOVA test, two-way ANOVA test, independent t-test, and paired t-test.

Concerning the marginal adaptation, the results showed that the marginal gaps of all groups were below the clinically acceptable limit (less than 120 μm), and crowns fabricated from the bioactive resin block and cemented with the bioactive cement showed the least marginal gap.

Concerning the fracture strength, the results of this study showed no statistically significant difference between the mean values of fracture strength of both block types with each cement type. Meanwhile, the adhesive resin cement RelyX Ultimate provided higher shear bond strength than the self-adhesive resin cement for both types of blocks with no statistically significant difference between both types of blocks ($p>0.05$).

Regarding the color stability, both block types showed color change within the clinically acceptable limit (less than 3.3) although Crios blocks showed less color change than the bioactive resin block with statistically highly significant difference ($p<0.05$).

Regarding the ion release, the fabricated block showed higher release of fluoride, calcium, and phosphate ions than the reinforced resin block with statistically highly significant difference ($p<0.05$).

The investigation of bioactivity revealed evidence of apatite formation in ACTIVA samples without any noticeable changes in the surface of Crios samples.

From the results of this study, the fabricated bioactive resin block seems a promising material for CAD/CAM applications in terms of marginal adaptation, facture strength, ion release, and bioactivity with comparable shear bond strength. However, the material may need further improvement in terms of finishing and polishing to enhance its color stability.