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Assessment of Bioactive Resin-Modified Glass Ionomer Restorative as a New CAD/CAM Material. Part I: Marginal Fitness Study

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Abstract

The objective of this *in vitro* study was to evaluate and compare the marginal fitness of monolithic crowns fabricated from a newly developed bioactive CAD/CAM resin block and reinforced resin CAD/CAM block pre-and post-cementation with adhesive and self-adhesive resin cements. Bioactive CAD/CAM block were fabricated from ACTIVA BioACTIVE-RESTORATIVE (Pulpdent Corporation, USA) using a clear rectangular Teflon mold. Thirty-two human maxillary first premolar teeth were prepared to receive full crowns then 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 the bioactive resin block, Group B: crowns fabricated from reinforced composite block (BRILLIANT Crios, Coltene). Each group was 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. The prepared teeth were scanned using CEREC Omnicam digital intra-oral and the crowns were then designed using CEREC Premium software (version 4.4.4) and milled using CEREC MC XL milling unit. The marginal gap of each crown was measured before cementation at four points on each tooth surface using a digital microscope at a magnification of 230x. Each crown was then cemented on its respective tooth according to the manufacturers' instructions of each cement, and the marginal gap was measured again at the same aforementioned points. The results of this study showed that the marginal gap of all groups are below the clinically acceptable limit. Meanwhile, the marginal gap of the crowns fabricated from both block types increased significantly after cementation with both types of cement. Pre-cementation, student's t-test revealed that there is no statistically significant difference in the marginal gap of crowns fabricated from both block types ($p > 0.05$). Post-cementation, a statistically highly significant difference was seen between both block types with both types of cement ($p<0.01$). From the results of this study, the newly developed bioactive resin block seems a promising material for CAD/CAM applications in terms of marginal fitness.

Keywords: *resin block, ACTIVA BioACTIVE, BRILLIANT Crios, CAD/CAM, marginal gap.*

Introduction

Marginal adaptation is a vital factor for long-term longevity and clinical success of dental restorations [1, 2]. Marginal discrepancies may lead to cement exposure to oral fluids, resulting in marginal microleakage and luting agent dissolution with percolation of bacteria, food and oral debris, potentially causing secondary caries, and periodontal disease [3, 4].

Numerous restorative materials for CAD/CAM systems differing in chemical structure and indications are now available on the dental market [5].

However, ceramic material has many disadvantages such as fragility, requirement of excess time for fabrication and abrasive effect. Additionally, low modulus of elasticity of ceramic material makes it unable to absorb the pressure of mastication. These disadvantages of ceramics have led to increased interest in resin composites CAD/CAM blocks [6, 7]. Their exceptional machinability, edge stability and reduced brittleness relieve some of the drawbacks of ceramic CAD/CAM blocks.

Bioactive materials have been used in almost all field of dentistry. However, bioactive materials have not yet been implied in the field of CAD/CAM materials. ACTIVA BioACTIVE-RESTORATIVE material a resin-modified glass ionomer that delivers all the advantages of glass ionomers in a strong, resilient, resin matrix. As claimed by manufacturer, it chemically bonds to teeth, releases more calcium, phosphate and fluoride and is more bioactive than glass ionomers. Moreover, this material is claimed to be more durable and fracture resistant than resin composites [8, 9]. ACTIVA material contains a rubberized resin component that makes them tougher and more resistant to fracture and chipping than composites [10, 11]. It doesn't contain Bisphenol A, Bis-GMA and BPAderivatives [12].

These positive characteristics of ACTIVA material encouraged the idea of developing a bioactive resin block for CAD/CAM applications that can release favorable ions and stimulate apatite formation in response to pH changes in the oral cavity.

The aim of this study was to assess the marginal fitness of crowns fabricated from the newly developed bioactive CAD/CAM blocks and compared with those fabricated from one of the commercially available resin blocks (BRILLIANT Crios) pre-and post-cementation with adhesive and self-adhesive resin cements.

Materials and Method

Bioactive resin blocks were fabricated from ACTIVA BioACTIVE-RESTORATIVE (Pulpdent Corporation, USA) using a clear rectangular Teflon mold. The internal dimensions of the Teflon mold size are in accordance with size14 CAD/CAM block. The material was injected directly in the mold using a disposable auto-mixing tips. A celluloid strip was then placed on the top surface of the mold and a glass slab was placed above. A 500 gm weight was placed above the glass slab to release air bubbles and remove excess material. A period of 30-seconds was waited to allow for the self-curing reaction to start. The mold was then placed in the chamber of UV light curing box (Vertex Eco Light Box, Netherlands, Holland) for 10-minutes. The block material was then separated from the mold by unscrewing of the base of the mold. A metal holder specially fabricated for this study was then fixed to the fabricated block.

Thirty-two sound human maxillary first premolar teeth extracted for orthodontic purposes were selected. Each tooth received tooth preparation for full crown in accordance with the guidelines of tooth preparation for full crown made from resin block. The prepared teeth were divided into two main groups of 16-teeth each according to the type of block used: Group A (study group): crowns fabricated from the bioactive resin block, Group B (control group): crowns fabricated from the reinforced composite block (BRILLIANT Crios, Coltene/ Whaledent AG, Switzerland). Each group was further subdivided into two subgroups of 8 teeth each according to the type of cement used for the cementation of the crowns: *Subgroup 1*: crowns cemented with adhesive resin cement (RelyX Ultimate, 3M ESPE, USA), *Subgroup 2*: Crowns cemented with self-adhesive bioactive resin cement (ACTIVA BioACTIVE-Cement, Pulpdent Corporation, USA). The prepared teeth were scanned using CEREC Omnicam digital intra-oral scanner. Crowns were designed using Sirona inLab CAD SW 15.1 and milled using inLab MC XL machine. Each crown was then seated on its respective tooth under a standard static load of 5 Kg. The vertical marginal gap of each crown was then measured using a digital microscope at a magnification of 230x. Measurement was done at four points predetermined on each surface of specimen using image-J software. Sixteen measurements were obtained for each specimen and the mean of these measurement was taken which represented the pre-cementation marginal gap. Each crown was then cemented on its respective tooth with either type of cement after surface treatment of the internal surface of the crown and the tooth following the manufacturers' instructions of the two types of cement. Crowns of both groups were sandblasted with 50 μm aluminum oxide. For group A, the internal surface was etched with phosphoric acid gel. For group B, ONE COAT 7 UNIVERSAL light-cured dental adhesive (Coltene/ Whaledent AG, Switzerland) was applied to the internal surface of the restoration according to the manufacturer's instructions. Teeth of subgroups A1 and B1 (cemented with RelyX Ultimate cement) were etched with phosphoric acid gel for 15 seconds, rinsed and dried, then Single Bond Universal Adhesive (3M ESPE, USA) was applied according to the manufacturer's instructions. On the other hand, teeth of subgroups A2 and B2 (cemented with ACTIVA cement) didn't receive any surface treatment prior to cementation. The internal surface of each crown was loaded with either type of cement and each crown was seated on its respective tooth using a dental surveyor under a constant static load of 5 Kg, followed by light curing for 20 seconds per surface

after removal of the excess cement. The specimen was then removed and kept on bench for one hour and then stored in distilled water for 24 hours [13]. Marginal gap was then measured again at the same points used four pre-cementation measurement. The recorded measurements were then statistically analyzed using students't-test at level of significance of 0.05.

Results

The descriptive statistics of the vertical marginal gap in µm of the two groups and their subgroups pre- and post-cementation are shown in Table (1) and Figure (1).

Table (1): Descriptive statistics of the marginal gap (in µm) of the different groups between blocks pre- and post-cementation.

Groups		Pre-cementation				Post-cementation			
Cement	Block	Mini.	Maxi.	Mean	SD	Mini.	Maxi.	Mean	SD
RelyX Ultimate	ACTIVA	39.130	60.861	45.145	7.100	43.517	89.613	63.331	15.123
	Crios	33.330	55.260	45.501	7.955	60.865	102.415	85.925	13.798
ACTIVA	ACTIVA	36.940	62.300	43.883	9.671	40.766	64.480	49.718	7.708
	Crios	32.989	55.247	41.336	6.704	55.410	105.250	75.890	17.021
Total	ACTIVA	36.940	62.300	44.514	8.222	40.766	89.613	56.524	13.560
	Crios	32.989	55.260	43.419	7.425	55.410	105.250	80.907	15.840

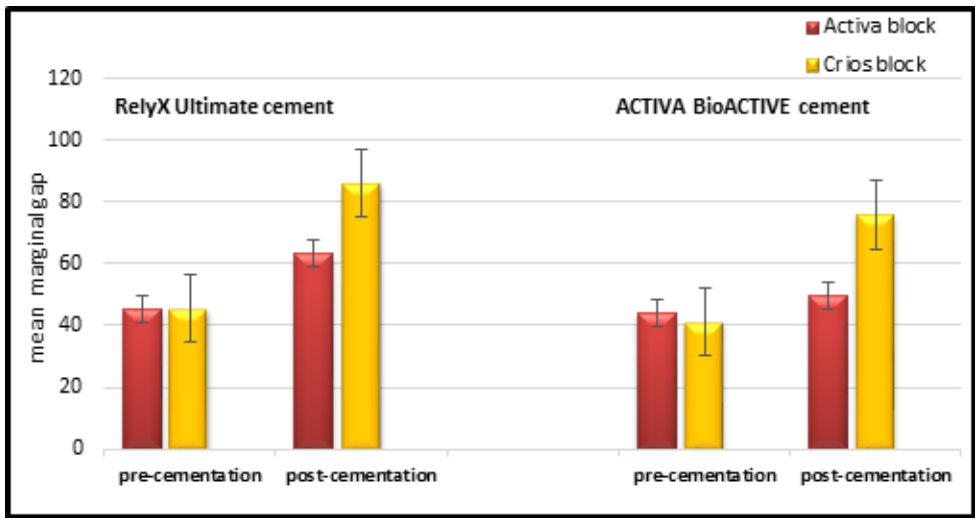

Figure 1: Cluster Bar-chart representing the means of the marginal gap (in µmm) of the different groups pre- and post-cementation.

From this table and bar-chart, it can be seen the lowest mean of marginal gap was recorded by subgroup A2, in which crowns were fabricated from ACTIVA block and cemented with ACTIVA cement (49.718), while the highest mean of marginal gap was recorded by subgroup B1, in which crowns were fabricated from Crios block and cemented with RelyX Ultimate cement (85.925). On the other hand, there was an overall increase in the marginal gap of all groups post-cementation.

The comparisons between the marginal gaps of both groups pre-cementation and post-cementation using student's t-test at a level of significance of 0.05 are shown in Tables (2) and (3), respectively.

Table (2): Student's t-test for comparison of significance of the marginal gap of the two groups pre-cementation.

Block type	Mean	SD	t	df	*p* value
A1	45.145	7.100	0.095	14	0.926 NS
B1	45.501	7.955			
A2	43.883	9.671	0.612	14	0.550 NS
B2	41.336	6.704			
ACTIVA	44.514	8.222	0.395	30	0.695 NS
Crios	43.419	7.425			

Table (3): Student's t-test for comparison of significance of the marginal gap of the two groups post-cementation.

Cement	Block type	Mean	SD	t	df	*p* value
Rely X Ultimate	A1	63.331	15.123	3.122	14	.008 HS
	B1	85.925	13.798			
ACTIVA	A2	49.718	7.708	3.962	14	.001 HS
	B2	75.890	17.021			
Total	ACTIVA	56.524	13.560	4.678	30	.000 HS
	Crios	80.907	15.840			

From these two tables, it can be seen there was no statistically significant difference between the two block types pre-cementation ($P > 0.05$), while statistically highly significant differences were seen post-cementation ($P < 0.01$).

On the other hand, further comparison for the effect of type of cement on the marginal gap of two block types was done.

Table (4): Student's t-test for comparison of significance of the effect of type of cement on the marginal gap of two block types.

Block type	Cement	Mean	SD	t	df	*p* value
ACTIVA block	A1	63.331	15.123	2.268	14	.040 S
	A2	49.718	7.708			
Crios block	B1	85.925	13.798	1.295	14	.216 NS
	B2	75.890	17.021			

The use of the ACTIVA cement resulted in significantly less mean marginal gap of crowns fabricated from the bioactive block than the RelyX Ultimate cement ($p<0.05$).

Discussion

The vertical marginal gap measurement is the most frequently used method to quantify the accuracy of fit of the restorations [14]. It is well-agreed among studies that marginal gaps less than 120 μm are considered clinically acceptable [15-17].

The results of this *in vitro* study showed that the marginal gaps of all groups pre-and post-cementation were below the clinically acceptable limit.

Before cementation, the statistically non-significant differences in the marginal gap between the two block types could be attributed to the standardized process in the fabrication of crowns (including standardized tooth preparation, scanning, designing, and milling), and the relative similarity in the basic composition of both block types as they belong to the same category of all-ceramic materials which is resin composite block. However, evaluating the marginal gap of crowns without luting them on their respective teeth is not reflective of clinical reality because the cement and cementation process play a relevant role in the final discrepancy achieved [18].

In this study, two types of resin cements that differ in their chemical composition and adhesive strategies (adhesive and self-adhesive) were selected.

After cementation, there was an increase in the marginal gaps of crowns fabricated from both block types and cemented with the two types of cements. This result is in agreement with other studies that found that the cementation procedure causes a significant increase in the vertical marginal discrepancy [18-20]. This might be due to the hydraulic pressure developed during cementation that is going to push the cement upward.

In the designing software of CAD/CAM system, the marginal spacer was set "zero", while the radial and occlusal spacer was set "100μm" starting 1mm above the finishing line. Therefore, when the crown carrying the cement is placed on the prepared tooth and pressure was applied, as the crown approaches the final position, there is no space for escapement of cement through the cervical marginal collar, resulting in great amount of luting cement to be accumulated on the occlusal surface of the prepared tooth that might interfere with proper seating of crown restoration, increasing the vertical marginal discrepancy [21].

The results of this study showed that the marginal gap of crowns fabricated from ACTIVA block and cemented with both types of cement were lower than those of crowns fabricated from Crios block with statistically highly significant differences. This could be attributed to that the cementation of restorations fabricated from Crios requires the application of one coat 7 universal adhesive to the inner surface of the restoration prior to cementation after sandblasting according to manufacturer's recommendations, owing to the high degree of polymerization of these blocks. This forms an additional interfacial layer between the restoration and the tooth that might interfere with adaptation of the restoration.

Concerning the type of cement, ACTIVA BioACTIVE self-adhesive cement exhibited less increase in the marginal gap with both block types than the RelyX Ultimte adhesive cement. This may be due to the difference in the bonding strategy between the adhesive and self-adhesive cements. Cementation of indirect restorations with self-adhesive cements reduces the number of application steps as compared to adhesive cements that require multiple interfacial bonding layers that may compromise adaptability. Additionally, it has been found that light curing of the adhesive prior to placement of resin cement produces thicker adhesive film thickness that may interfere with the seating of the restorations [21]

Conclusions

1. Crowns fabricated from the bioactive resin blocks showed better marginal fitness post-cementation than those fabricated from Crios blocks regardless of the type of cement used.

2. The marginal gaps of crowns fabricated from both block types increased significantly post-cementation.

3. Crowns cemented with the self-adhesive cement showed better marginal fitness than those cemented with adhesive cement irrespective of the type of block material.

Ethical Clearance: The Research Ethical Committee at scientific research by ethical approval of both environmental and health and higher education and scientific research ministries in Iraq

Conflict of Interest: The authors declare that they have no conflict of interest.

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