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BIOACTIVE RESIN MODIFIED GIC *VS*. CONVENTIONAL ONE: IN VIVO AND IN VITRO STUDY

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ABSTRACT

PURPOSE: To evaluate the bioactive resin modified GIC material (Activa) *vs*. conventional one (Vitremer) clinically and laboratory.

Materials & Methods: Clinically: Fifteen healthy children of both sexes aged (4-7) having a bilateral similar initial occlusal caries on the lower 2nd primary molars were selected. A split-mouth design was used where conventional Class I cavities were prepared on carious molars. One side was restored with Activa and the contra-lateral side restored with Vitremer (control). The patients were recalled for clinical evaluation at 3, 6 and 12 months postoperative. The modified United States Public Health Service (USPHS) evaluation criteria were used. **Laboratory**: included: 1. Mechanical strength tests (compressive and diametral tensile). **2.** Shear bond strength test between both restorative materials and dentin. **Statistical analysis:** Mann Whitney test was used for clinical evaluation, while t-test and ANOVA were used for laboratory evaluation. The significance level was set at $P \leq 0.05$.

Results: Clinically: The overall clinical outcome showed no significant difference between both groups in all evaluated criteria ($p>0.05$). **Laboratory:** Activa showed higher values than Vitremer in all tested groups and the differences were significant ($p<0.05$)

Conclusion: Activa recorded better scores than Vitremer in nearly all tested clinical criteria but without significant differences between them during recall-time intervals. But, the laboratory differences in all tested groups were significant.

KEYWORDS: Bioactive resin modified GIC, Conventional resin modified GIC, Mechanical tests, Shear bond strength.

INTRODUCTION

Children are more susceptible to lose their natural teeth structure as a result of high caries index and great exposure to traumatic factors. Unfortunately, natural tooth structures have no or very limited capacity to regenerate and this necessitates replacement of such natural structure by suitable restorative materials. These materials should restore and maintain form, function, esthetic

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of natural teeth, and preserve the remaining tooth structure [1]. In pediatric dentistry, restoration of carious primary teeth is very important not only for their healthy growing and psychological factors but also for developing permanent dentition in physiological non-disrupted manner [2].

Conventional glass ionomer cements (CGICs) have many properties that make them a leading restorative material such as direct chemical bonding to tooth structure, antibacterial & anti-cariogenic activities as a result of fluoride release, mild pulpal irritation, and negligible dimensional changes during setting that minimize the microleakage compared to composite resin [3,4]. Moreover, CGICs can be used in many clinical situations, such as cementation for indirect restorations, liner or base material, especially under composite restorations, and as esthetic restoration in primary dentition and in low stress bearing areas [3-5].

On the other hand, conventional GICs still have some drawbacks that limit their usage to non-stress bearing areas, as attack by moisture during the initial setting period, short working time, long setting and maturation time which dictates postponing the finishing and polishing procedure to an additional visit, low mechanical properties, low fracture toughness, high abrasiveness and exhibiting very low wear resistance [3-6].

In an attempt to improve the physical and mechanical properties of CGICs and overcome the previously mentioned problems at 1980's, a resin portion was added to the original cement producing a hybrid material called resin-modified glass-ionomers (RMGICs). As RMGICs set on exposure to light, dentists have a complete control on working time, and they can finish and polish the restoration immediately after light-curing, and this eliminates the need for an additional visit as done with unmodified GICs. The RMGICs showed higher flexural and diametral tensile strengths and less sensitivity to moisture than conventional GICs [7-9].

The bioactive smart restorations have been introduced in dental markets and many dentists became interested in them, as they behave favorably in moist oral environment with the capability to release and recharge with fluoride, phosphate, and calcium. These smart materials counteract the demineralization of tooth structure and aid in its remineralization [10].

Activa is a newly developed bioactive restoration that mimics the physical and chemical properties of the teeth. So, it is expected that this material has better properties which combine the esthetic, resilience, and strength of composite with the bioactivity properties of GIC and RM GICs [11].

Hence, the present study aimed to compare the bioactive-restorative material 'Activa' with the conventional RMGIC 'Vitremer' clinically and laboratory.

MATERIALS AND METHODS

I- Clinical evaluation:

Study design

This controlled clinical trial was carried out to evaluate the clinical performance of Activa (Pulp-dent corporation, USA) versus conventional one, Vitremer (3M ESPE, Dental Products) in restoring the second primary molars.

Patient selection

In this study, fifteen healthy children of both sexes were included, aged 4-7 (mean age 5.5 years) with bilateral, nearly similar and initially decayed occlusal surfaces of lower 2nd primary molars. All included children were selected from out-patient clinic in the Department of Pedodontics, Faculty of Dentistry, Tanta University. The aim of the present study was explained to the parents of all participants

and informed consents were obtained according to the guide lines on human research published by the Research Ethics Committee, Faculty of Dentistry, Tanta University.

Criteria for teeth selection:

Inclusion Criteria:

- Initial bilateral occlusal caries in lower second primary molars.

Exclusion criteria:

- Extensive carious lesion.
- Uncooperative patients.
- Current systemic diseases.
- Handicapped children.
- Patients with para-functional habits or dental malocclusion.
- Children having any clinical symptoms or signs of pulp involving.
- The parents and children who not be willing to return for follow-up visit and assessments.

Group assignment:

The thirty selected lower 2nd primary molars were divided into two groups (15 molars/each). A split-mouth design was used where one side was selected randomly for group I (Activa) and the contralateral side for the group II (Vitremer).

Clinical procedure

Tooth isolation was accomplished using cotton rolls. The outline form of the prepared Class I cavity was restricted to the carious lesion using #4 fissure diamond bur at high speed under cooling spray (1.5 mm cavity depth from cavosurface margin and the width was about 1/3rd of the distance between lingual and buccal cusps) [12]. The treatment was completed according to the grouping.

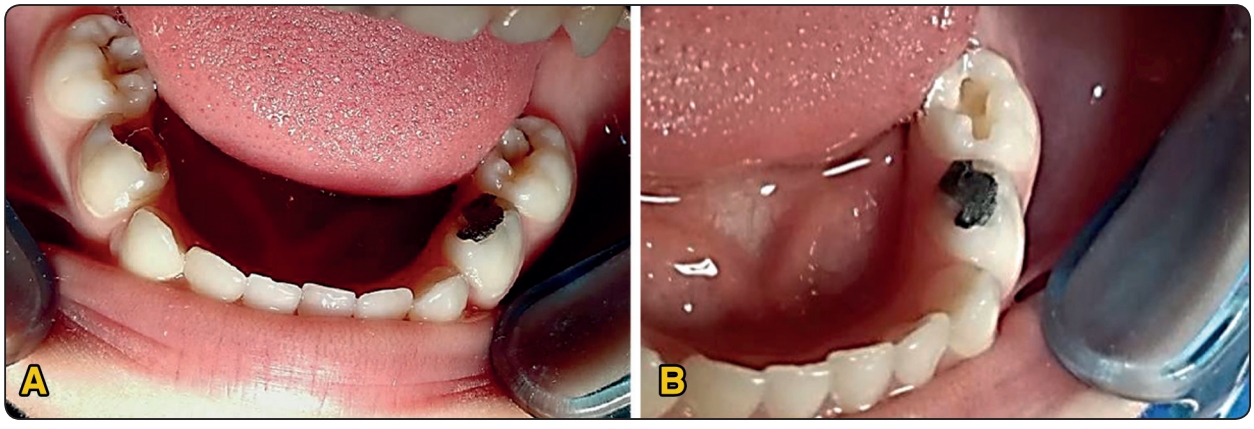
Group I (study group):

The prepared cavity was etched for 10 sec 37% phosphoric acid gel (UltraEtch; Ultardent, USA), rinsed of and dried. Great care was taken during drying to avoid desiccation of natural tooth structure.

The Activa syringe with its mixing tip was inserted into Activa-Spenser and snapped into place using firm pressure. According to the manufacturer's instructions, the mixed material was dispensed into the prepared cavity from the bottom to the top using gentle pressure, left alone for about 20 sec to allow the polyacid component to etch the tooth structure, and then light-cured for 20 sec using (Optilux curing light; Demetron/Kerr,USA). (Fig 1)

Group II (control group):

After application of GC Dentine conditioner (3M ESPE, Dental Products) in the prepared cavity, Vitremer primer was applied on clean dried dentin



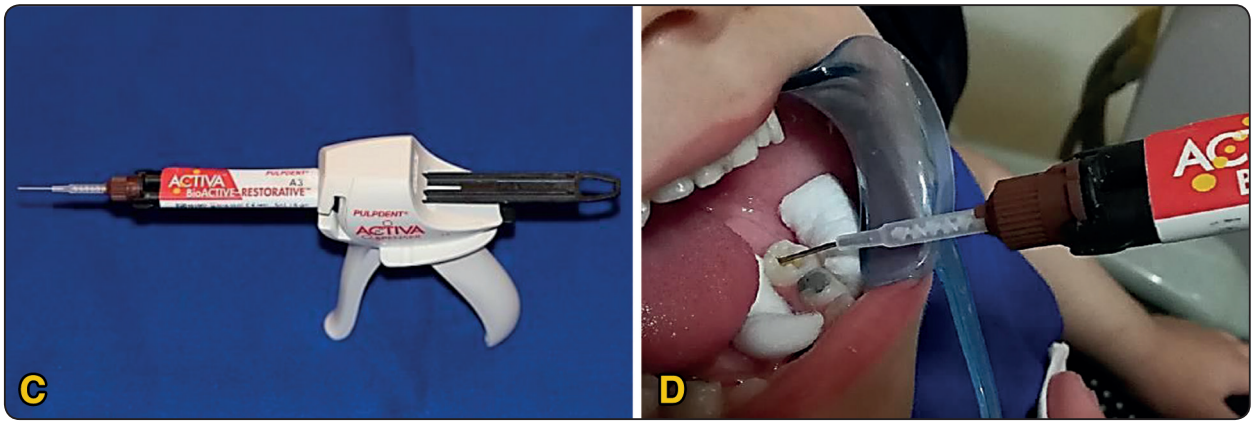


Fig (1). Preoperative photograph showed bilateral simple class I caries of lower 2nd primary molars indicated for Activa and Vitremer filling (A). The outline form of the cavity prepartion of Lt 2nd primary molar (B). The Activa syringe with its mixing tip loaded the Activa-Spenser and snap into place (C). Injection of Activa into the prepared cavity using mixing tip loaded in Activa-Spenser (D).

surface for 30 sec, dried for another 15 sec, and then light-activated for 20 sec.Vitremer mixture was transferred into a delivery tip, loaded into compules tips gun, syringed into the cavity, and then light-cured for 60 sec (Fig 2). After initial setting, the restoration was coated with cavity varnish.

For both groups, the occlusal adjustments were carried out by tungsten carbide bur under water cooling spray, then the restoration was finished and polished with aluminum-oxide disks, and finally photographed immediatly after polishing and at each recall visit using an 18-megapixel digital camera (Canon, EOS, 600D, Japan) at an illumination of 5000 K ± 10% for color matching.

All patients were directed to maintain good oral hygienic measure, and recalled for clinical evaluation of restoration at an interval of 3, 6 and 12 months postoperatively, using the modified United States Public Health Service (USPHS) criteria as first described by Cvar and Ryge[13] and adapted by Wilson et al.[14] for retention, color matching, marginal discoloration, anatomic form, marginal adaptation, and secondary caries (table 1).

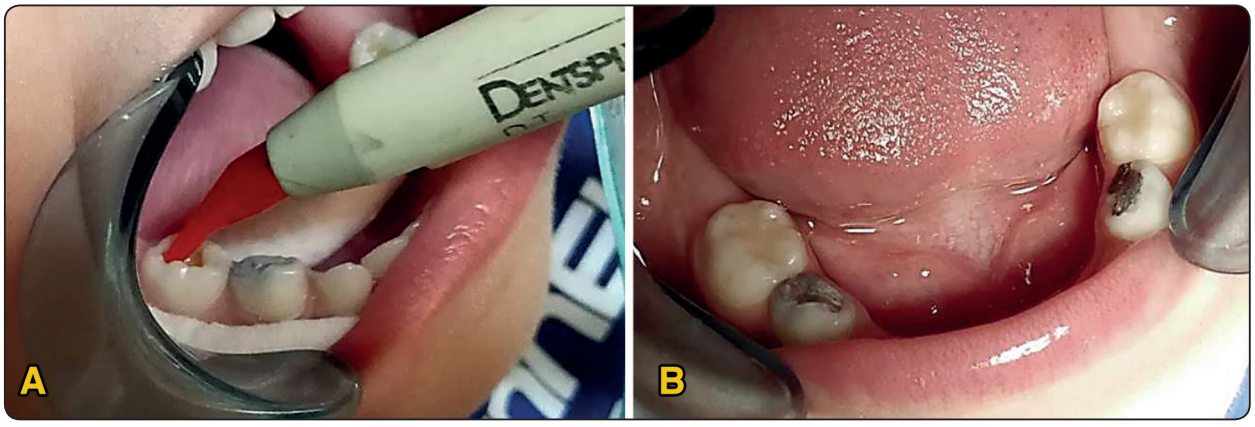


Fig (2). Photograph showed the injection of Vitremer into the prepared cavity of lower Rt 2nd primary molar using delivery tip loaded in compules tips gun (A).

Restorations were scored as follows:

TABLE (1) Modified USPHS evaluation criteria.

Category	Rating and criteria
Retention	• Alfa: Intact and fully retained restorative material. • Bravo: Partially retained of restorative material • Charlie: Complete loss of restorative material.
Color match	• Alfa: Match tooth. • Bravo: Acceptable mismatch. • Charlie: Unacceptable mismatch.
Marginal discoloration	• Alfa: No discoloration. • Bravo: Discoloration without penetration in pulpal direction. • Charlie: Discoloration with penetration.
Marginal adaptation	• Alfa: Closely adapted, no visible crevice. • Bravo: Visible crevice, explorer will penetrate. • Charlie: Crevice in which dentin is exposed.
Secondary caries	• Alfa: No visual evidence of caries at the junction of the restoration. • Bravo : Visual evidence of caries or dark deep discoloration at the junction of the restoration.
Anatomic form	• Alfa: Continuous. • Bravo: Slight discontinuity, clinically acceptable • Charlie: Discontinuous, failure.

Dental operating light, diagnostic disposable clean mouth mirrors, and sharp dental explorers were used during evaluating all previously mentioned criteria.

II-Laboratory evaluation:

Laboratory evaluation of both restorative materials was achieved through:

A. Mechanical strength tests (compressive and diametral tensile).

B. Shear bond strength (SBS) between both restorative materials and dentin.

A: Mechanical strength tests:

For compressive strength test, sixty cylindrical specimens were prepared (with 4±0.1 mm diameter and 6±0.1 mm length) [15], using split cupper mold (Fig 3). Thirty specimens were prepared from each restorative material; group I was prepared from Activa, while Group II from Vitremer.

For diametral tensile strength test, sixty cylindrical specimens (9±0.1 mm diameter and 4.5±0.1mm height) [16], were prepared from another split cupper mold (Fig 4). Again, thirty specimens were prepared from each restorative material, Group I and Group II, from Activa and Vitremer, respectively. These molds helped us to prepare specimens with accurate and reproducible dimensions.

All specimens were kept in relative humidity of about 90% at 37°C for 1 h before separating them from the mold. Then specimens were immersed in distilled water at temperature of 37 °C, and maintained in the incubator for additional 23 hrs, 7 days and 14 days before mechanical testing. For each immersion time, ten specimens were prepared.

Fig (3). Split cupper mold for compressive strength test.

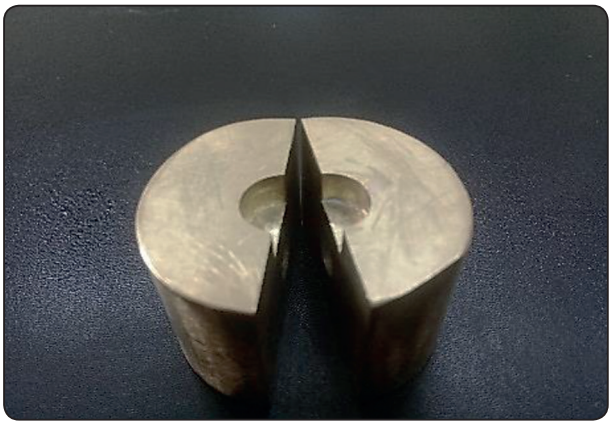


Fig (4). Split cupper mold for diametral tensile strength test.

Compressive strength test

After a well-controlled storage time, cylindrical specimens for the compressive strength test were loaded to measure compressive strength on universal testing machine (Instron Model 3365; Tensile Tester 5 KN. USA). The cross-head speed was adjusted at 1.0 mm·min^{-1}. (Fig 5)

Compressive strength (CS) was calculated by the following equation:

$$CS=4P/\pi d^2$$

Where **P** is the load at fracture in newton (N) and **d** is the diameter of the cylindrical specimen (mm).

Diametral tensile strength test:

Diametral tensile strength (DTS) was measured on cylindrical specimens after a well-controlled storage time on the same Instron universal testing machine, at cross-head speed (0.5 mm·min^{-1}). (Fig 6)

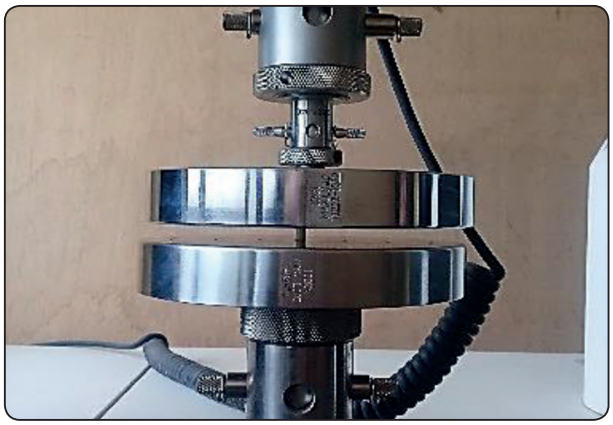


Fig (5). Compressive strength testing.

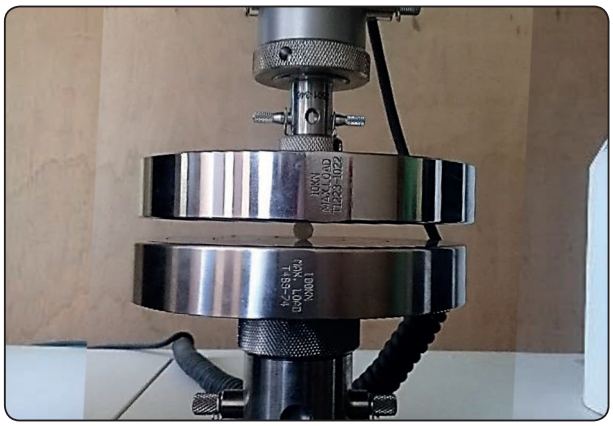


Fig (6). Diametral tensile strength testing.

Diametral tensile strength was calculated using the following equation:

$$DTS=2P/\pi dt$$

Where **P** is the load at fracture in newton (N), and **d** is the diameter in (mm) and **t** is the thickness of the cylindrical specimen in (mm).

B: Shear Bond Strength Test:

In this study, thirty sound second primary molars with intact crown were collected. These teeth were extracted due to physiologic reasons. Teeth with carious lesions, fractured during extraction, showing any structural defects such as hypoplastic, hypomineralized lesions or having any type of developmental anomaly were rejected and excluded out of the study.

Immediately after the extraction, teeth were cleaned from tissue remnants and debris using periodontal curettes and ultrasonic scaler, then, they were autoclaved (Autoclave Dental X-Domina Plus B, Italy) in individual plastic vials with distilled water for 15 minutes at 121°C [17].

All teeth were used within 3 months of collection and stored in refrigerated saline solution at 5 °C until use to avoid the teeth dehydration and microbial growth**,** according to International Organization for Standardization (ISO) norms recommendation (ISO, Guidance on testing of adhesion to tooth structure) [18].

Crowns of the thirty collected primary molars were separated from their roots at cemento-enamel junction, then, each crown was sectioned mesiodistally into two halves parallel to the long axis using diamond disc at low speed and under continuous water cooling to minimize heat generation and eliminate the risk of burning of natural tooth structure. The separation of thirty primary molar crowns yielded sixty specimens.

All specimens were horizontally embedded in a cylindrical aluminum mold (3.5 cm length x 3 cm diameter) with the aid of non-split Teflon disc that fits the inner surface of the mold and have a central depression to localize the specimens in central repeated positions (Fig 7A). Autopolymerizing resin (Acrostone, Cairo, Egypt) was used to fill the mold leaving the buccal or palatal surfaces facing upward and parallel to the ground. Great care was taken to avoid any contamination of the experimental surfaces with acrylic resin.

The experimental dentinal surfaces were subjected to sequential gentle, mechanical treatment with 120, 280, 400, and finally 600 grit wet silicon carbide paper until getting flat, yellow dentinal surfaces. Final smoothing of the specimens was achieved using a slurry of pumice and water.

In order to demarcate the bonding area on each specimen, an adhesive tape with central punch out hole of 4 mm in diameter was used only on the prepared dentin surface. The prepared specimens were divided randomly into two groups: group I, for application of Activa, while group II, for application of Vitremer. Each group contains thirty specimens, i.e. ten specimens for each immersion time (24 hrs, 7 days and 14 days).

Another Teflon disc which was centrally split and had a central hole of 4 mm diameter and 3mm thickness was used to build up the restorative materials. This split disc fits the inner surface of metallic cylinder and was perfectly positioned over the specimen in coincidence with the central hole of demarcated area on dentin surface of each specimen. Then, the specimens became ready to receive the special treatment (as mentioned before in clinical study) indicated by each manufacturer before the application of each restorative material. (Fig 7B)

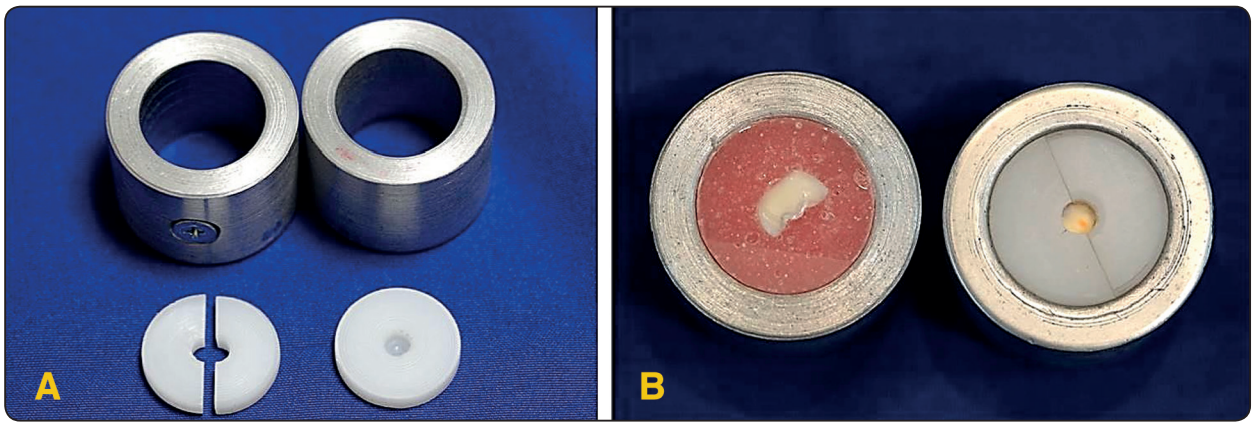


Fig (7). Alumiuim cylinderical mold, split (Lt) and non split teflon disc with a circular central depression (Rt) (A). A specimen was horizontally embedded into the acrylic mold and the specimen before material application (B).

Group I

Using Activa-Spenser, the Activa restorative material was mixed and dispensed directly into the central hole of perfectly oriented split Teflon disc, and finally, light-cured for 20 sec. The light curing was achieved through bulk-curing technique from the top of the restoration (Depth of curing is 4mm according to manufacturer instructions). After careful removal of Teflon disc, an additional curing of the restorative material for 20 sec was occurred.

Group II

The Vitremer mixture was syringed into the central hole of perfectly oriented split Teflon disc, and then light-cured for about 60 sec. Light curing was achieved though bulk-curing technique followed by curing for additional 60 sec when Teflon-mold was removed.

In order to resemble clinical condition for 6 months, all specimens in both groups were thermo-cycled for 600 cycles from 5 °C to 55 °C with 30 sec dwell time, and 20 sec transfer time [5,8]. Any specimen showing any degree of dislodgment or separation was rejected and replaced.

The specimens in both groups were randomly subdivided into three subgroups, (n=10) according to the storage period (24 hrs, 7 days and 14 days, respectively). The specimen stored in artificial saliva in an incubator at 37°C. The storage media were changed every 3 days to maintain the pH at 7.6 and prevent the bacterial growth. At the end of each storage time, the specimens became ready to measure shear bond strength.

Shear bond strength test

Shear bond strength was assessed on the same universal testing machine. Samples that embedded in acrylic resin were secured accurately in a jig attached to the base plate of the testing machine.

A chisel-edge plunger was mounted in the movable crosshead of the testing machine and positioned such that the leading edge was perpendicular to dentin-restorative interface (Fig 8). The crosshead speed for load application was (0.5 mm/min). The load in Newtons (N) required to debond the restorative cement was recorded, and then, the corresponding shear bond strength in megapascal (MPa) was calculated by dividing this debonding force value by the bonded area (A) in mm^2. (MPa) = 1 N/mm^2

The surface area (A) was calculated through the following equation:

$A = \pi r^2$ Where $\pi = 3.14$ & $r = 2$

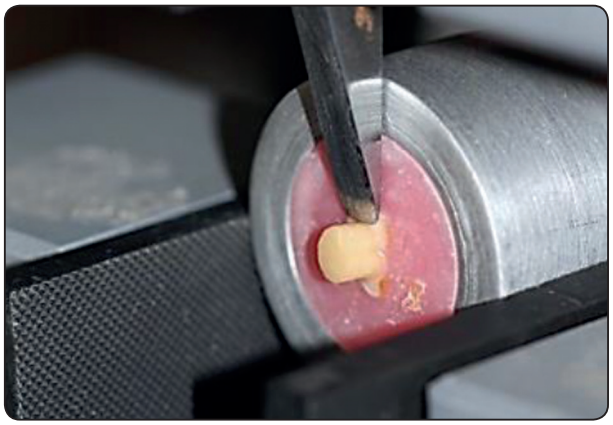


Fig (8). The mounted specimen in Instron machine during shear bond strength test.

Statistical analysis

All collected data were tabulated and statistically analyzed using SPSS, version 20.0 (IBM, Illinois, Chicago, USA). The mean and standard deviation values were calculated for each group. Mann Whitney test and Wilcoxon test were used for clinical evaluation, to compare between two groups in non-related and in related samples, respectively, while for laboratory evaluation, t-test and ANOVA were used to compare between two groups in non-related and related samples, respectively. The significance level was set at $P \leq 0.05$.

RESULTS

I-Clinical Evaluation

The overall clinical performance showed that there was no significant difference between the groups in all categories of criteria during the different time recall interval (p>0.05).

At 3-month recall-time, all categories of criteria in both restorative materials groups recorded 100% alpha scores and the differences were not significant (p>0.05). At 6-month of follow up**,** in Vitremer group, there were only two cases (13.3%) displayed 'Bravo score' of color match, two cases (13.3%) displayed 'Bravo score' of marginal discoloration, and another case (6.7%) exhibited discontinuity of anatomic form 'Bravo score'. However, Activa group recorded 100% alpha score for all experimentally evaluated criteria (table 2), and the differences were not significant (p>0.05).

At 12-month of follow up, Activa group recorded only 2 cases (13.3%) with 'Bravo score' in color match and another case (6.7%) displayed 'Bravo score' in marginal discoloration. While in Vitremer group, there were 4 cases (26.7%) that showed 'Bravo score' for color match, 3 cases (20%) with 'Bravo score' in marginal discoloration and anatomic form, while the marginal adaptation and secondary caries recorded 'Bravo score' in 2 cases (13.3%) (table 3), and the differences were not significant (p>0.05).

TABLE (2) Comparison between studied groups at 6 months recall-time.

Groups	Criteria Score	Color Match		Marginal Discoloration		Anatomic form		Marginal Adaptation		Secondary Caries		Retention	
		n	%	n	%	n	%	n	%	n	%	n	%
Activa no= 15	Alpha	15	100%	15	100%	15	100%	15	100%	15	100%	15	100%
	Bravo	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Vitremer no= 15	Alpha	13	86.7%	13	86.7%	14	93.3%	15	100%	15	100%	15	100%
	Bravo	2	13.3%	2	13.3%	1	6.7%	0	0%	0	0%	0	0%
p-value		0.539		0.539		0.775		1.00		1.00		1.00	

No= 15 ****Significant at p <0.05***

TABLE (3) Comparison between studied groups at 12 months recall-time.

Groups	Criteria Score	Color Match		Marginal Discoloration		Anatomic form		Marginal Adaptation		Secondary Caries		Retention	
		n	%	n	%	N	%	n	%	n	%	n	%
Activa no= 15	Alpha	13	86.7%	14	93.3%	15	100%	15	100%	15	100%	15	100%
	Bravo	2	13.3%	1	6.7%	0	0%	0	0%	0	0%	0	0%
Vitremer no= 15	Alpha	11	73.3%	12	80%	12	80%	13	86.7%	13	86.7%	15	100%
	Bravo	4	26.7%	3	20%	3	20%	2	13.3%	2	13.3%	0	0%
p-value		0.539		0.539		0.367		0.539		0.539		1.00	

No= 15 ****Significant at p <0.05***

II- Laboratory Evaluation:

Activa restorative material recorded higher strength properties (compressive and diametral tensile) in comparison to the Vitremer (table 4), and all the differences were significant ($p < 0.001$). Within the same group, whether group I or II, the change in storage time has a significant effect on both evaluated strength properties ($p < 0.001$) with the highest values were recorded after 7 days of storage and the lowest after 14 days of storage time.

As regard to shear bond strength, Activa restorative material showed higher shear bond strength to the primary teeth dentin than Vitremer one, and the differences were significant ($p < 0.001$) (table 5). Also, the change in storage time has a significant effect on shear bond strength between both evaluated restorative materials and primary teeth dentin where ($p < 0.001$), with the highest values recorded after 7 days of storage time, and the lowest after 14 days.

TABLE (4) The mean, standard deviation (SD) values of compressive and diametral tensile strength in MPa of all studied groups.

Variables		Compressive & Diametral Tensile strength in MPa						*P-value*
		Subgroup A *24 hours Storage*		**Subgroup B** *7 days Storage*		***Subgroup C*** *14 days Storage*		
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Activa (Group I)	**CS**	271.10^{B}	1.85	277.70^{A}	2.21	257.70^{C}	2.06	**<0.001***
	DTS	33.90^{B}	1.66	39.20^{A}	1.32	31.40^{C}	1.07	**<0.001***
Vitremer (Group II)	**CS**	164.90^{B}	3.07	177.80^{A}	5.88	156.20^{C}	1.69	**<0.001***
	DTS	23.70^{B}	1.06	27.00^{A}	1.70	21.30^{C}	1.03	**<0.001***

Means with different capital letters in the same row indicate statistically significance difference. *; significant (p<0.05). ns; non-significant (p>0.05)

TABLE (5) The mean, standard deviation (SD) values of shear bond strength in MPa of all groups.

Variables	Shear bond strength in MPa						*P-value*
	Subgroup A *24 hours Storage*		**Subgroup B** *7 days Storage*		**Subgroup C** *14 days Storage*		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Activa (Group I)	12.10^{aB}	0.26	13.38^{aA}	0.28	11.13^{aC}	0.49	**<0.001***
Vitremer (Group II)	8.31^{bB}	0.17	9.26^{bA}	0.29	7.71^{bC}	0.34	**<0.001***
P-value	**<0.001***		**<0.001***		**<0.001***		

Means with different small letters in the same column indicate statistically significance difference; means with different capital letters in the same row indicate statistically significance difference. *; significant (p<0.05) ns; non-significant (p>0.05)

DISCUSSION

The success of restorative materials depends on biological, physicochemical, and mechanical properties [19]. The micromechanical and adhesive bonding to tooth structure are very important to minimize and prevent microleakage with subsequent developing of hypersensitivity, pulp reaction, and secondary caries [20].

With continued development in material science, many different bioactive materials with variable forms and compositions became widely used in every field of dentistry. These materials have many uses in the field of conservative dentistry for regeneration, repair, and/or reconstruction [21,22].

Bioactive restorative resin material combines the best advantages of composite and glass ionomers without compromising anyone. It combines the potential for remineralization, high-aesthetics, chock absorbent, fluoride release with high physico-mechanical properties. It contains a bioactive matrix of ionic resin and reactive fillers of glass ionomer that mimic the physico-chemical properties of teeth structure. Also, it regulates the natural chemistry of both teeth and saliva and contributes to the maintenance of tooth structure and oral health [21]. Hence, this study was carried out to evaluate the bioactive resin-modified GIC "Activa" versus conventional "Vitremer" clinically and laboratory.

The age of the patients selected ranged from 4-7 years, where communication is easier above 4 years, and the time of exfoliation is still far away at 7 years which may compromise the clinical outcome [23]. The split-mouth technique used in this study was considered the best study design to standardize all in vivo oral condition for both restorative materials [24]. Modified of USPH criteria used in this study is due to its valid and most widely used criteria for comparison purpose among studies at different observation periods [25].

In this study, the parameters of marginal discoloration and adaptation of restoration are used as an indicator of the esthetic maintenance or deterioration and the microleakage potential, while loss of anatomic form could be explained as being consistent with material deterioration that may affect its durability. In addition, the color change of restoration may be an indicator of surface change, while the secondary caries is often interpreted as a function of the material characteristics, if all other disturbing factors such as the cavity, the technique, the operator, or the patient are kept to a minimum [26].

The clinical results of this study showed that Activa group recorded slightly better parameter's scores than Vitremer group but without significant difference. This may be attributed to several advantages, such as the ionic resin matrix, bioactive fillers that mimic the natural teeth properties with regard to its physical and chemical properties, and the low polymerization shrinkage compared to resin-based composite restorative materials [11]. This agree with Croll et al. [27] and Sidhu & Nicholson [28] who stated that the Activa has physical properties closely resembling the strengths and wear resistance of resin-based composites, combined with the bioactivity capabilities harmonious of GIC systems that release active biologic ions of fluoride, phosphate, sodium, and silicate into the surrounding environment at biologically beneficial levels.

The Activa group at 12 months displayed 100% alpha score for anatomic form, marginal adaptation, secondary caries, and retention while recording 93.3% and 86.7% alpha score for marginal discoloration and color match, respectively. These results compared to the study of Abou Aly et al. [29] who found that 100% alpha score for anatomic form, secondary caries, and retention, while 95% alpha score was recorded for marginal adaptation and discoloration,

According to the evaluation criteria, Vitremer recorded 100% for retention. This finding is comparable to the results of Sengul & Gurbuz [30], Casagrande et al. [31], and Qvist et al. [32] who reported

91%, 95% and 98% for retention, respectively. For both secondary caries and marginal adaptation, the results were 86.7% Alpha score compared to the findings of Croll et al. [33] and Sengul & Gurbuz [30], who reported 98% and 100% for Secondary caries, respectively, while the studies of Mjör et al. [34] and Sengul & Gurbuz [30] demonstrated 100% for marginal adaptation.

In this study, the color match reported 73.3% alpha score which disagrees with the result of Sengul & Gurbuz [30] who reported 100%. The anatomic form and marginal discoloration recorded 80% Alpha scores at the end of recall time in comparison with the result of Neo et al. [35] who displayed 86% and 76% for anatomic form and marginal discoloration, respectively. These differences may be attributed to the dissimilarities in the sample size, mean age of children, recall time, and the cavity sizes [30].

Evaluation of strength, whether compressive or diametral tensile, of the two restorative material is very important, as they bond chemically to the tooth structure through ion exchange reaction, and always the failures in the bond between these restorative cements and tooth structure are cohesive in nature within cement rather than adhesive at the tooth-cement interface. Therefore, any weakening in the mechanical properties of the cement material could compromise the adhesion junction. For brittle materials such as glass ionomer cements and their modified types, it was highly recommended to determine diametral tensile strength instead of tensile strength [36].

The rate of clinical success of any intra-oral restorative materials depends mainly upon sealing ability and good adhesion of such restoration with tooth structure, and its resistance to various dislodging forces acting within the oral cavity. These bonds are not only important between restoration and tooth structure to prevent microleakage and minimize pulp irritation, hypersensitivity, or secondary caries but also, between cement base and tooth to remain in its place under masticatory function or during the application overlying restorative material [3,37].

Although there are many different methods that can be used in vitro to evaluate the longevity of the bond strength to tooth structure but the shear bond strength test has been widely used as it is considered to be easy and reproducible [6]. Shear bond strength could be defined as, the resistance to forces that tend to slide restorative material past tooth structure. As the major dislodging forces at the tooth restoration interface are of shearing type, so this type of strength is of greater importance to be determined than any other types of intra oral stresses [3].

In this study, both compressive and diametral tensile strength in all tested groups recorded initially low values at 24 hrs of storage time and high values after 7 days. This may be explained by incomplete maturation of glass ionomer cement matrix within the first 24 hrs, followed by complete matrix maturation and maximum hydration of the crosslinked polycarboxylate network within the next 7 days of storage time [6,38,39]. This is in accordance with the study of Cefaly et al. [40], who reported that the strength properties of RMGICs increases with the time from 1 h to 1 week. The increase of time may be attributed to the setting reaction of GICs as aluminium polycarboxylate is more stable and improves the mechanical strength properties of the cement that takes a longer time to be formed than calcium polycarboxylate [40].

In the current study, Activa showed higher mechanical strength properties than Vitremer, This may be due to shock absorbing capacity of the bioactive resin matrix in Activa, in addition to the presence of bioactive glass particles which are able to release more fluoride than GICs [11,21].

The diametral tensile strength of Activa in this study ranged from 31.4 to 39.2 Mpa. This is in agreement with Sharafeddin et al. [5], who found that diametral tensile strength of reinforced RMGICs, varied from 31.3 to 35.9.

The shear bond strength of Vitremer in this study was varied from 7.71-9.26 Mpa. These findings are in agreement with the results of Suryakumari Nujella et al. [41] and Pisaneschi et al. [42] who reported 9.71 and 7.04-10.30 Mpa, respectively. However, these findings are disagrees with Shebl et al.[6] who demonstrated 6.7-12.07 Mpa.

On the other hand, higher shear bond strength values of Activa to dentinal tooth surface in this study, may be explained by the presence of ionic resin matrix in Activa which contains phosphate acid groups, on ionization of such groups in the presence of water, hydrogen ions break off and are replaced by calcium ions in the tooth structure. This ionic interaction binds the resin to the tooth minerals, forming a very strong resin-hydroxyapatite complex and a strong positive seal against microleakage. Moreover, bioactive materials have minimal polymerization shrinkage in comparison to conventional resin-based composite and have also the ability to stimulate the remineralization process of tooth structure. All these properties gave the bio-active materials a great chance to minimize gap formation at the tooth-restoration interface and improve bond strength [21].

In this study, the highest shear bond strength values of both restorative materials were recorded after 7days of storage time and this may be explained by that bonding between tooth structure and glass ionomer is based mainly on hydrogen bond and over time it becomes more mature and evolves into a stronger chemical bond [43].

The compressive, diametral tensile and shear bond strength tests in all groups in this study recorded a slight reduction in their values after 14 days of storage time. This may be attributed to slight hydrolysis within the polymeric matrix by aging in storage media due to hydrophilic nature of both restorative materials [6].

CONCLUSION

Activa bioactive restorative material had a significant improvement in vitro evaluation compared to conventional RMGIC Vitremer. While the in vivo evaluation showed a slight improvement but in a nonsignificant manner.

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