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Evaluation the Element of Three Bulk Fill Resin Base Composite Aging in Artificial Saliva by SEM/EDX Analysis: A Comparative Study

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Abstract

Background: Bioactive resin composites are aimed to discharge remineralizing ions, raise pH levels, and precipitate hydroxyapatite, thereby enhancing effectiveness of restorations.
Aims: this study focused on evaluate and compare element analysis of restoration /dentin interface by SEM/EDX of conventional and bioactive bulk fill composite.
Materials and Methods: A total of sixty extracted maxillary premolars was used. Teeth were divided into three groups based on the composite type: Group A (Tetric Power Fill), Group B (Predicta Bioactive), and Group C (Cention Forte). Each group was further subdivided into two subgroups: one without storage and one stored in artificial saliva for 30 days. The occlusal dentin exposed by sectioning 2 mm below the deepest occlusal point, and restorations was placed using the bulk-fill technique. Then the samples sectioned vertically in a mesiodistal way, and restoration–dentin interface was analyzed by SEM/EDX for elemental composition.
Results: Cention Forte (storge group) exhibited highest Ca/P ratio (4.01±1.98), followed by its (non-storge) (1.97±0.38) while Predicta Bioactive showed high value in (storge group) (2.71±0.34). There was significant difference of Tetric power fill with both Cention Forte and predicta bioactive between non-storage and storage groups at ($p \leq 0.05$).
Conclusion: The SEM /EDX analysis exhibited an increase the Ca/P ratio in dentin area corresponding to both Cention Forte and Predicta Bioactive. Consequently, based on current study outcomes, these materials may be designated as bioactive bulk fill resin restorative materials.

Introduction:

Throughout recent years, the need for composite resin in dentistry for aesthetic and restorative applications has grown. For restoring the form, function, and appearance of teeth, it became the main option. Consequently, it is now a crucial part of current aesthetic dentistry [1].The incremental filling procedure has become known as the gold standard for resin composite application; however, it presents many disadvantages, including increased chair time, the possibility for gaps between increments and adhesion complications between layers. Additionally, enhancing the number of increments produces greater pressure on the tooth structure and the tooth-restoration connection[2].The improvement in chemical composition of resin, Filler technology, and the integration of different photoinitiator systems led to the creation of bulk-fill composite, an advanced class that focusses on time efficiency and procedure simplification[3] .The bulk-fill composite resin provides the production of resin restorations more than 4 mm in a single layer with no affecting on the curing depth, due to its excellent translucency and effective polymerization control [4][5] . Tetric PowerFill is an advanced bulk-fill nanohybrid composite that includes chemical modifications in its organic matrix, photoinitiators, and filler components that promote homogeneous and rapid polymerization. These innovations improve handling and mechanical properties, making it more appropriate for clinical applications[6]. The bioactivity of dental resin is defined as "the ability of material to release remineralizing ions, enhance pH levels and facilitate the precipitation of hydroxyapatite." These materials may maintain the integrity of the interfacial adhesive by promoting remineralization through hydroxyapatite layer formation at the tooth-restoration connection, thus marginal spaces will be seal and inhibiting penetration of bacteria [7].Many bioactive composites have been produced, among which Predicta Bioactive, a bulk-fill resin composite developed for direct restorations. The producer asserts that it exhibits higher compressive, tensile, and flexural strengths, while simultaneously releasing F, Ca, and P ions to promote the production and remineralization at the tooth-material interface ,Cention Forte, a novel alkasite material introduced in 2021, comes in capsule form. The manufacturer claims that this material can release fluoride (F-), calcium (Ca^{+2}), and hydroxide (OH^-) ions. Cention Forte is provided with a primer specifically designed for use with it, as recommended by the manufacturers[8-10]. Since the restoration's composite-tooth interface is weak area, so researchers have been working on producing new bioactive dental materials that interact with dental tissue in specific manner[11]. The aims of this study was to evaluate and compare element analysis of restoration /dentin interface by SEM/EDX of conventional and bioactive bulk fill composite . The null hypothesis states that there is no significant difference in the ca/p ratio of conventional and bioactive bulk-fill dental restorative materials to sound dentin after aging in artificial saliva

Materials and Methods

Ethical approval

An etheical approval was received from the "Research Ethics Committee" College of Dentistry, Mosul University (no. UoM. Dent.25/1013).

Methods

Sample Collection, Selection, Cleaning and Sterilization

In vitro lab study sixty maxillary premolar teeth extracted for orthodontic purposes from patients aged 14 to 30 years were collected for the current study from various health centers in Mosul city,2025 . Each tooth was examined using a stereomicroscope (china) at 10X magnification. The examination excluded teeth that exhibited any defects or flaws. The teeth were cleansed using ultrasonic scalers(Woodpcker, Germany) to remove debris, calculus, and periodontal attachment. Subsequently, they were polished with pumice (free of eugenol) (DARMA,USA) using a rubber brush

(China) and a low-speed handpiece, and consequently rinsed with distilled water. The teeth samples were subsequently prepared for the subsequent mounting stage, after being stored in deionized water until the time of the study[12-14].

Mounting of the Teeth and Construction of the Acrylic Block.

A retentive tube, polyvinyl chloride (PVC) (China), in diameter 2cm and in length 2cm, was utilized

as a mold for fixing the teeth. with an cold cure acrylic resin(S.A Colombia) in dough stage each tube was filled and with the aid of a dental surveyor (China) each tooth was positioned and a sticky wax(Hoppegarten, Germany) was used to attach the tooth to the rod of the surveyor, the selected teeth with their roots were embedded at the tube center and parallel to its long axis to a level of 2 mm below the cement-enamel junction as the position of the tooth in the alveolar bone [15][16].

Design of Study

Sixty teeth were randomly selected into three groups based on the type of composite restorative materials (20 teeth for each group). Subsequently, each group was further divided into two subgroups. The first subgroup (10 teeth) was not stored, while the second subgroup (10 teeth) was stored in artificial saliva for 30 days. Subgroups will be examined for element analysis of restoration /dentin interface by SEM/EDX **.**

Sample Preparation

The occlusal dentin of each tooth was exposed by cutting 2mm under the deepest point of the occlusal surface of the crown, determined by measuring the depth of the deepest pit and subtracting it from 2mm from the marginal ridge. This incision was performed using a diamond-coated separating disc((C03/190 -0.25mm) china) connected to a slow-speed handpiece (China) with water coolant. The cut was made at a right angle to the longitudinal axis of tooth. The occlusal dentin surfaces of all specimens were polished with 600-grit wet silicon carbide abrasive paper(China)in a circular motion under running tap water ten times to provide a smooth dentin bonding surface[13][17]**.**

Application of Restorative Materials

Application of Adhesive System: For Predicta Bioactive bulk fill resin composite and Tetric Power Fill,the manufacturer's recommendations were followed, and an etch and rinse protocol was used. The dentin surface was exposed, and 37% Phosphoric acid gel (Spident, Korea) was applied for 15 seconds, followed by a 15-second rinse with water. The teeth were dried for 5 seconds using oil-free air[18]. G-Premio Bond (Universal Bond Quick, GC, Japan) was applied in one layer to the dentin surface using a microbrush(China) according with the manufacturer's instructions. For 10 seconds the bond was allowed to remain on the dentin surface before being dried at the maximum airflow rate for 5 seconds. Finally the adhesive layer was light-cured for 10 seconds at a light intensity of 1000 mW/cm2 using a light-emitting diode light curing unit (Rogin Dental, China) set at a distance of 1mm[19].

Placement of Restorative Materials

A Custom made Teflon mold (Made Locally)was designed to standardize bulk fill composite application on bonded dentin to produce a 4mm diameter and 2mm height[17].Each restorative material was applied as in the following:

Tetric Power Fill (Ivoclar Vivadent, Schaan, Liechtensin) the composite was applied to the bonded dentin in a single increment and subsequently adapted to fill the mold using plastic instruments (China).

Predicta Bulk Bioactive(Parkell, USA). Composite was delivered on bonded dentin by a spiral nozzle to fill the mold and express the composite slowly and then withdraw the tip, to eliminate air entrapment keeping the tip immersed in the material, initially undergo a 30 sec. self-cured before light cured to minimize shrinkage stress.

Cention Forte (Ivoclar Vivadent,Schaan,Liechtenstein)

The primer was put as just one drop in a dish and mixed with the applicator for 5 seconds, applied to the dentin for 10 seconds, and then air-dried for 5 seconds (self- cure)[20] . Cention Forte capsules were activated by pressing the plunger on a flat surface to allow mixing of the powder and liquid. Immediately after activation, the capsule was inserted in the amalgamator (capsule mixer) (Softly8 ,ITALY)and mixed for 17 sec. at room temperature (21°C) (low temperature led to delay setting of material). After mixing, immediately the capsule was placed into the applicator(GC ,Tokyo, Japan) ,clicked 3 click and dispensed to fill the mold , keeping the tip immersed in the material to prevent the formation of air bubbles[21]. For all restorative materials, a celluloid strip (China) was put over the restoration to achieve a smooth, flat surface and to avoid formation of oxygen inhibition layer. By a light-emitting diode (LED) curing device with an intensity of 1000 mW/cm² (ROGIN DENTAL, CHINA) in single application for 20 seconds the material was cured. light-curing point was placed perpendicular to occlusal surface of restorative material, maintaining a standardized distance of 1 mm (equal to the thickness of a metal plate from a custom-made Teflon mold). After polymerization, the celluloid strip was removed, and any excess material was carefully excised using a sharp scalpel. Once the material was set, the metal plate and custom-made Teflon mold was removed extra curing was took place for 20 seconds on each side of the restorative material to improve polymerization[13][22][23] .

Storage Procedure

The teeth samples for each groups of (20 teeth) were subdivided into two subgroups(10 teeth) as follows:

•**First Subgroup not Stored in Artificial Saliva** :All samples of sub-groups were stored in plastic container(China) containing 30 ml of deionized water in an incubator (BINDER , Germany) at (37± 2)°C in 95% humidity for 48 hours before **SEM/EDX analysis**[14][24][25].

•**Second Subgroup Stored in Artificial Saliva**: In up righting position to the base of plastic container, all samples of storage sub-group were adapted and then each plastic securely- covered container occupied with 30 ml artificial saliva (PH.7) and incubated (BINDER , Germany) at (37 ± 2) °C and 95 humidity for periods of 30 days and replenished every week until the end-point time (30 days) [26][27].

Elemental analysis of Resin /Tooth Interface Using SEM/EDX

Sectioning and Preparation of the Sampls

From each additional subgroups (non-storage and storage in artificial saliva for 30 days), ten teeth samples were subjected to vertically sectioned in mesiodistal direction into two roughly equal halves along their long axes in a perpendicular direction to the restoration dentin interface and then the teeth were horizontally sectioned at level of CEJ to be separated from the acrylic resin using a diamond disc at low speed with water coolant(china) during the cutting procedure to avoid heat generation as showing in Figure (1), one of the obtained sections from each sample was randomly selected to be polished using fine silicon carbide papers graded from 400, 600, 800, and 1000 grits ten time in a circular motion under running water coolant to get a smooth and shiny surface, the samples were put in ultrasonic bath(GRANBO, China) with deionized water for 10 min in order to eliminate any debris [28][17].The samples were dried and kept dry for 24 h before being kept out of water to avoid over hydration during the teeth gold plating. A gold sputter coating evaporator was used to sputter coat the teeth two times. The teeth were then inspected using a SEM with an accelerating voltage of 30 KV, working distance of 9-13 mm, and were imaged at magnifications of 10000X[29][30] . The second uncoated half of the obtained sections from each sample were employed normally for elemental analysis using EDX, which is connected to SEM, following EDX analysis of the resin/dentin interface using EDX software coupled to a field emission SEM. By concentrating a radiography beam on the resin/dentin interface, a chemical analysis was carried out. Since the most significant minerals are Ca and P ions , the values reported indicate their mineral weight percentages [31].

Statistical Analysis : it was performed using SPSS version 23. Data normality was checked with the Shapiro–Wilk test (p = 0.05), and since the data were normally distributed, parametric tests were applied. Duncan's multiple range test was utilized for determining significant differences among groups at $P \leq 0.05$.

Results

Representive SEM images analysis.

SEM imaging was performed at10000X magnification to examine the restorative material/ dentin interface in both non-storage and storage groups in artificial saliva to assess the bonding changes and precipitation of hydroxyapetite at this area. For Tetric Power Fill SEM imaging at10000X magnification for the restorative material/ dentin interface in both non-storage and storage groups in artificial saliva showed no crystal-like hydroxyapatite deposition as shown in Figure (2). In Predicta Bioactive SEM imaging at10000X magnification for the restorative material/ dentin interface in non-storage group showed low deposition of crystal-like hydroxyapatite while for storage group there was high precipitation of hydroxyapatite as showen in Figure (3). For non-storage group of Cention Forte, SEM imaging at10000X magnification showed deposition of crystal and layer like hydroxyapatite at the restorative material/ dentin interface and for storage group ,SEM imaging represent heavy precipitation of hydroxyapatite as shown in Figure (4).

Representive EDX analysis

This analysis was conducted to investigate alterations in chemical composition at two important regions,the restoration margin and coronal dentin margin close to the restorative material. This investigation attempted to identify compositional alterations related to ageing in artificial saliva. The percentages by weight of calcium and phosphorus were employed to calculate the calcium/phosphorus ratios.

EDX elementary analysis for all restorative material core.

As shown in Table (1), the mean Ca/P ratio of Tetric powerFill was zero for both groups(non –storage and storage).confirmed the SEM analysis (no sign of apatite precipitation at the surface). In storage group The mean Ca/P ratio of Predicta Bioactive was (1.84±0.71) above the natural HA(1.67) .This indicate formation of apatite, confirming the SEM that demonstrated apatite deposition close to restoration border . the mean Ca/P ratio of Cention Forte for groups of storage in artificial saliva was (2.63±0.63) which is higher than the ratio for natural HA (1.67). This could mean that apatite deposition was happening, which would support the SEM analysis that showed apatite deposition at the restoration border. The results of Duncan's multiple range test about the interaction of Ca/P ratio with every type of restorative materials and storage conditions, as presented in **Table (2),** showed that there was no statistically significant differences between Predicta Bioactive and Cention Forte in Ca/P ratio(1.52±0.60) and (1.97±0.87) respectively, while Tetric power Fill represented statistically significant difference(0.00±0.00).

EDX elementary analysis for coronal dentin tooth samples.

In Table(3) The mean Ca/P ratio of Tetric powerFill for non- storage is (1.75±0.35) within the natural HA ratio (1.67) for dentin. While storage group , the coronal dentin margin near to the Tetric power Fill showed Ca/P ratio (1.77±0.17) that within the normal dentin HA ratio .The EDX elementary analysis for non-storage group of the **Predicta Bioactive** exhibited a mean Ca/P ratio of (1.81±0.45), significantly above the natural hydroxyapatite (HA) ratio of dentin (1.67), suggesting a composition similar to native minerals content. Subsequently,in storage group, the Ca/P ratio at the coronal dentin margin increased to (2.71 ± 0.32). The rising ratio, significantly above that of natural dentin hydroxyapatite, indicates the development and deposition of a hydroxyapatite-like layer**.** The average EDX elements for the coronal dentine region adjacent to Cention Forte (non-storage group) showed a mean Ca/P ratio (1.97±0.38), which is slightly greater than the natural HA ratio of 1.67 for dentin. the coronal dentin area closest to Cention Forte in storage group had a Ca/P ratio of about (4.01±1.98**),** which above the natural HA ratio for dentin, confirming HA precipitation . The finding of Duncan's multiple range test regarding the interaction between the Calcium and phosphorus ratio for the coronal dentin-restoration interface area and storage conditions, as illustrated in Table(4), indicate no significant differences between Predicta Bioactive and Cention Forte, with Ca/P ratios of 2.23±0.59 and 2.99±1.74, respectively. In contrast, Tetric Power Fill exhibited a statistically significant difference with ratio of 1.79±0.45.

Discussion

The definition of "bioactive" will be different according to the situation of its application. In dentistry, the capability of them to release ions like as calcium, phosphorus, and fluoride, hence promoting remineralization and the formation of hydroxyapatite crystals upon interaction with physiological fluids, is known as bioactivity [32-35] . A high Ca/P ratio is an important indicator of remineralization, facilitating the assesment of a material's acceptability for application on demineralized dental tissue. The natural Ca/P ratio in natural dentition is 1.67; a ratio below this value indicates a non-stoichiometric crystal characterized by calcium deficiency.[36][37]**.** EDX For Tetric Power Fill, there is no alteration in the Ca/P ratio, and no apatite-like crystals can be observed in the SEM images of the restorative material surface and the restoration/dentin interface in both non-storage and storage groups (0.00±0.00 to 0.00±0.00) (1.77±0.17 to 1.81±0.45), respectively. This conclusion corresponds to Dahiya (2023)[38], which anticipated that Tetric Power Fill, being an inert material, would not release any ions. However, it did release some ions, but not significantly, as shown by the immersion research, while X-ray microtomography (XMT) found no indication of apatite formation. Tetric Power Fill includes glass-based composite resins filled with fluoride; however, they lack bioactivity towards the underlying tissues due to their inability to release fluoride ions in quantities adequate for remineralization. The need for bonding systems additionally inhibits their bioactivity, and the matrix consists of photocured (biostable) resin [39][40]. The step-growth polymerization utilising β-allyl sulfone results in a more stable polymerization, eliminating unreacted monomers, which contributes to the poor solubility of Tetric PowerFill [41][42]. Scanning electron microscopy at higher magnification supported these findings, confirming the absence of apatite-like crystals at the interface of restorative materials and dentin in both non-storage and storage groups of tooth samples. Non-storage groups of both Cention Forte and Predicta Bioactive demonstrated no significant variation in the Ca/P ratio when compared with storage groups. This can be attributed to that the current study use of light cure with high-intensity (1000 mW/cm² for 10 seconds), which resulted in a covalently bound or less hydrophilic matrix. Consequently, the capacity of the light cure mode to release Ca ions reduced, while the self-cure mode released substantially higher levels of Ca ions than the light-cure mode[43]. This may also be related to the adhesive system that be used for predicta bioactive which forming a hybrid layer that inhibits the diffusion of calcium and phosphate ions into the dental structure [31]**.** For Cention Forte this can be attributed to its fillers, which include three inorganic glasses: barium alumino-silicate glass, calcium barium alumino-fluoro-silicate, and a basic calcium fluoro-silicate glass known as a “Alkasite” filler[44]. These components facilitate the formation of a superficial layer of calcium fluoride and calcium phosphate, measuring 0.5 mm in thickness, on the surface of Cention Forte during the initial phase of setting reactions. This layer exhibits resistance to dissolution in deionized water for a period of time [(45)]. This conducted with Kasraei *et al.,*2021[(46)]who showed that the phosphate ion release from Cention N bioactive materials significantly increased as the storage time increased 24 h to 48 h, and 6 months in distilled water. In this study ,the storage media was artificial saliva with pH=7 at 37^0C temperature for 30 days that is preferable environment for ion-release restoration to releases Ca, F, and P ions, which results in the formation of apatite on its surface [(9)].These results conducted with Shaymaa and Suliman, 2024 [(47)] which evaluates and compares the bioactivity of several restorative materials, finding that over 28 days, Cention Forte produced hydroxyl apatite precipitation on its surface, which confirms the findings of the current study about the storage groups of both Cention Forte and Predicta Bioactive.EDX revealed differences in both the restorative materials surface and the area of the coronal dentin-restoration interface on tooth structure in Cention Forte and Predicta Bioactive indicated their bioactivity by increase the Ca/P ratio of restorative material surface for Predicta Bioactive and Cention Forte (1.21±0.20 to1.84±0.71), (1.31±0.12to2.63±0.63) respectively and also for restoration/ dentin interface (1.75±0.35to2.71±0.34),(1.97±0.38to4.01 ±1.98) respectively after storage in artificial saliva at pH =7 in 37°C temperature for 30 days. This finding in agreement with Di Lauro *et al*., 2023[(48)] which evaluated the effect of pH and temperature on the ion release of a resin-based material containing alkaline fillers and a self-setting high-viscous glass ionomer cement the highest amount detected at pH = 6.8 was at 37 °C after 28 days which is comparable to the condition of the current study. In neutral and alkaline solutions, Ca and PO_4 ions can be precipitated as apatite [(49)(50)]. SEM at high value for Cention Forte and Predicta Bioactive confirmed these findings, demonstrating the formation of apatite at the interfacial area of the restoration/ tooth and this agrees with study conducted by Gjorgievska *et al*. 2008 and Fahmy *et al*. (2021))[(51)(52)] which they examined the bioactivity of restorative materials and found that crystal formation at the restoration/ tooth interfaces provides a sign of bioactivity and demonstrates the capacity of these materials to close gaps . The results of the current study exhibited no significant difference in the Ca/P ratio between the surfaces of both restorative materials and the coronal dentin-restoration interface in Cention Forte and Predicta Bioactive, regardless of non-storage or storage conditions. The solubility of the restoration, ion concentration, temperature, duration, and environmental pH all influence the quantity of released ions. The releasing of ions accelerates as pH drops and samples remain in water for long periods at high temperatures [(53-55)] **.** Cention Forte primer and Predicta Bioactive involve HEMA, a hydrophilic monomer; high hydrophilicity promotes absorption of water, resulting in hydrolytic dissolution [(56)] with increased their solubility, that explain their ability to release more ions and enhance their bioactivity. Even though was no significant different in Ca/P ratio in both Cention Forte and Predicta Bioactive in non-storage and storage groups. However, in storage groups, the Ca/P ratio of Cention Forte is higher in both the restorative material surface and restoration/dentin interface (2.63±0.63),(4.01±1.98) respectively than Predicta Bioactive(1.84±0.71),(2.71±0.34) respectively, This occurrence can be related to the presence of alkaline fillers that exhibit a great attraction for water[(57)] **.** During contact with saliva, alkaline fillers facilitate the dissolution and release of three salts (Na_2O, CaO, CaF_2) within SiO_2. Calcium, fluoride, and hydroxide ions are dependent on pH, promoting the formation of apatite in vitro on dentin at a pH = 7, if phosphate is available combine with a specified primer [(58)]**.** The in vitro method of this study might have fundamental limitations in accurately representing all possible intra-oral conditions, as the usage of extracted teeth, lacking of blood flow, prevents the replication of the dynamic oral environment characterized by variables such as pulpal pressure, fluid flow, and varying pH levels.

Conclusion:

Within the study's limitations, Cention Forte and Predicta Bioactive have an important effect after preservation in artificial saliva through improving interfacial durability due to their capacity to generate hydroxyapatite (HA) at the restoration-tooth contact.

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Conflicts of Interest: No conflicts of interest exist.

Figure(1): Tooth sample after sectioning

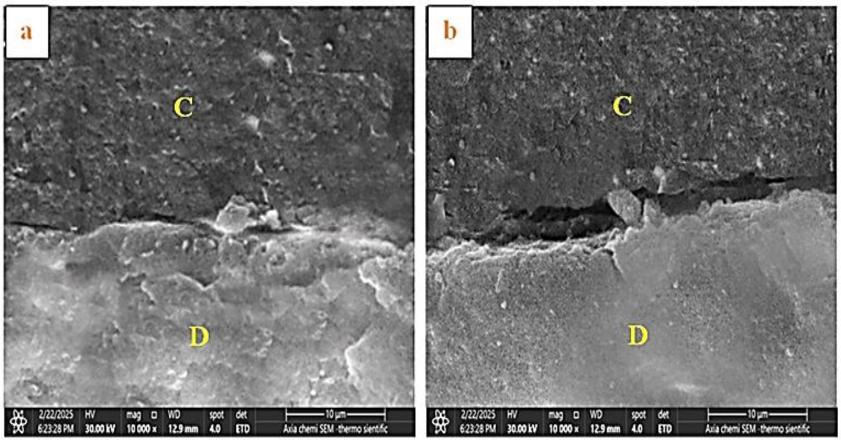

Figure (2): The SEM image at10000X magnification for restorative material /dentin interface of Tetric Power Fill :(a); non-storage (A1) (b);after storage in artificial saliva (A2) both images showed no crystal-like hydroxyapatite deposition at the interface. Note: C: composite , D: Dentine

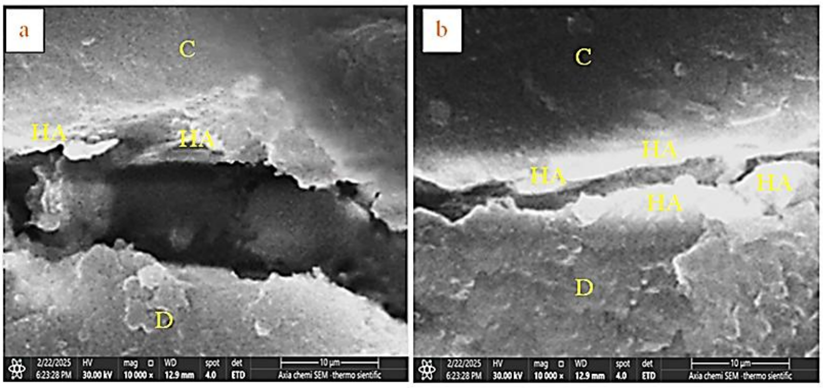

Figure (3): The SEM image at10000X magnification for restorative material /dentin interface of Predicta Bioactive:(a); non-storage (B1) showed slightly precipitation of hydroxyapetite on the margin of both restoration and dentin (b);after storage in artificial saliva (B2) showed crystal-like hydroxyapatite deposition at the interface. Note: C: composite , D: Dentine

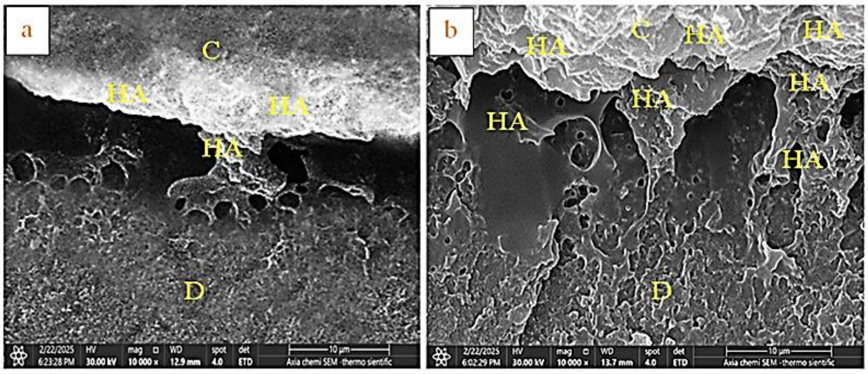

Figure (4): The SEM image at10000X magnification for restorative material /dentin interface of Cention Forte :(a); non-storage (C1) showed slightly precipitation of hydroxyapetite on the margin of restoration and hydroxyapatite layers at the interface (b);after storage in artificial saliva (C2) showed high crystal-like hydroxyapatite deposition at the restoration /coronal dentin interface. Note: C: composite , D: Dentin.

Table (1): The mean and standard deviations of calcium, phosphorus, and calcium-to-phosphorus ratio of all samples of materials (both non-storage and storage in artificial saliva groups) determined by EDX analysis

Non- storage groups				
Groups	N	Ca Mean±SD	P Mean ± SD	Ca/P Mean ± SD
A1:Tetric power fill non-storage	10	4.82±1.76	0.00±0.00	0.00±0.00
B1:Predicta bioactive non-storage	10	18.79±2.21	15.91±3.60	1.21±0.20
C1:Cention- Forte non-storage	10	19.65±3.91	14.95±3.28	1.31±0.12
Storage groups				
A2:Tetric power fill Storage	10	8.25±1.69	0.00±0.00	0.00±0.00
B2:Predicta bioactive storage	10	8.10±2.19	4.87±1.93	1.84±0.71
C2:Cention- Forte storage	10	17.87±4.53	6.80±1.08	2.63±0.63

Table(2): Duncan's Multiple Range Test testing the relationship between the Ca/P ratio under non-storage and storage circumstances for restorative materials.

Groups	N	Non-storage Mean±SD	storage Mean ± SD	Mean ± SD	Duncan grouping
Tetric power Fill	20	0.00±0.00	0.00±0.00	0.00±0.00	**b**
Predicta Bioactive	20	1.21±0.20	1.84±0.71	1.52±0.60	**a**
Cention- Forte	20	1.31±0.12	2.63±0.63	1.97±0.87	**a**

Table (3): The mean and standard deviations of calcium, phosphorus, and Ca/P ratio for the overall coronal dentin-restoration interface area (both non-storage and storage in artificial saliva groups) as determined by EDX analysis.

Non storage groups				
Groups	N	Ca Mean±SD	P Mean ± SD	Ca/P Mean ± SD
A1:Tetric power fill non-storage	10	20.15±3.95	11.58±1.88	1.75±0.35
B1:Predicta bioactive non-storage	10	3.86±1.58	2.30 ±1.10	1.81±0.45
C1:Cention- Forte non-storage	10	18.44±3.82	9.40±1.13	1.97±0.38
Storage groups				
A2:Tetric power fill Storage	10	3.85±1.42	2.36±1.13	1.77±0.17
B2:Predicta bioactive storage	10	28.50±4.09	10.63±1.82	2.71±0.34
C2:Cention- Forte storage	10	28.177±5.13	8.25±2.99	4.01±1.98

Table(4): Duncan's Multiple Range Test assessing the relation between Ca/P ratio and storage factor levels on the coronal dentin-restoration interface area

Groups	N	Non-storage Mean±SD	storage Mean ± SD	Mean ± SD	Duncan grouping
Tetric power Fill	20	1.77±0.17	1.81±0.45	1.79±0.45	**b**
Predicta Bioactive	20	1.75±0.35	2.71±0.34	2.23±0.59	**a**
Cention- Forte	20	1.97±0.38	4.01±1.98	2.99±1.74	**a**

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