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EFFECT OF TWO SURFACE TREATMENTS AND AGING ON COLOR STABILITY OF REPAIRED HYBRID CERAMIC

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ABSTRACT

STATEMENT OF PROBLEM: However, the repair of fractured ceramic restoration is the most reasonable and practical alternative treatment, the repair is a challenging clinical situation because after repair the color of the restoration may change as it ages under various physical and chemical conditions.

Objective: The aim of the present study was to evaluate the effect of two surface treatments and ageing on the color stability of hybrid ceramic repaired with resin composite.

Materials and Methods: The specified vita enamic ceramic blocks (14*14 mm) were sliced into discs with constant thickness of 1mm using a low speed; high precision Isomet diamond saw 4000****. Before repair, and specimens were aged for one month at 37 °C in a water bath. Specimens were divided into two equal groups Aaccording to surface treatment, the first group (n=8) treated by 9% HF followed by application of silane coupling agent and universal bond and second group (n=8) treated by 9%HF followed by application of universal bond. Repair was performed by packing the composite repair material using a Split Teflon mold (1mm thickness) placed on treated the hybrid ceramic samples. After repair, the samples were thermocycled (5000 cycles: 5–55°C; cyclic). The repaired samples were immersed in coffee solution under the controlled temperature 37°C. Color stability was measured by VİTA Easy shade Compact.

Results: There was significant difference in color stability for repaired samples before and after aging and staining. The color changes of repaired samples in all groups were above the clinically acceptable value (ΔE ≥3.3).

Conclusion: Based on the type of composite used in present study, there was perceptible color change in the repaired samples.

KEYWARDS: Hybrid ceramic, surface treatment, repair, discoloration

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INTRODUCTION

Because of patients' increasing aesthetic demands, Inlays, onlays, veneers, crowns, and bridges fabricated from all ceramic have become increased in recent years.[1] Alternatively, In clinical use, ceramic restorations are susceptible to fractures[2]. trauma, ceramic brittleness [3], and parafunctional habits have all been linked to the fracture of all-ceramic restorations[4]. Due to their brittleness, some ceramics are susceptible to chipping [3]. As a result, the polymer-infiltrated ceramic-network (PICN) material (also known as hybrid material) was developed, which is composed of a sintered ceramic network (86% in weight) infiltrated with a polymer matrix (14% in weight)[5,6].The polymer infiltrated ceramic was created with the goal of combining the benefits of both ceramic and composite materials. Repairability, low wear and abrasiveness of the opposing teeth and polishability are all advantages of composites. The combination of glass ceramics and resin produces synergistic effects that closely resemble natural dentition, giving dentists another treatment option in digital dentistry.[7] When the following factors are considered: replacement cost, loss of tooth structure, and additional trauma to the tooth, replacing a fractured restoration is not always the most practical solution.[8]

In case of localized fractures, intraoral repair may be a better alternative treatment to restoration replacement, which is clinically unacceptable and no longer viable [9,1]. Intraoral repair is a minimally invasive treatment that involves the placement of resin material with or without surface treatment in fractured restoration [1]. To improve the functionality, longevity, and durability of aesthetic of fractured ceramic restorations, several repair protocols have been developed, including etching with acid (e.g., hydrofluoric acid, acidulated phosphate fluoride, and phosphoric acid) [10], abrasion with aluminum oxide particles, and airborne abrasion with silica coating particles[11]. Chemical adhesion and micromechanical interlocking to the ceramic restoration surface are required for a strong resin bond, which requires surface roughening for adequate surface activation[12]. Surface conditioning of glass ceramics may be better achieved through hydrofluoric (HF) acid etching and silanization[13]**.** A well-established conditioning method for promoting resin-based material adhesion to feldspathic, leucite, and lithium-disilicate glass-ceramic restorations is hydrofluoric-acid etching accompanied by silanization [14]. One of the most common surface pretreatments for vitreous ceramics is the application of hydrofluoric acid etching and sandblasting with aluminium oxide particles, or a combination of two[15]. And through dissolving of the glassy phase from ceramic matrix, HF etching produced micromechanically retentive rough surface. It also enhances the formation of hydroxyl groups and became exposed on the ceramic surface.[16] To improve bond strength, a equilibrium between the hydroxyl groups of the inorganic substrate and the hydrolysable functional groups in the silane is needed[16].

The use of a silane coupling agent enhances the bond strength to vitreous ceramics by improving the union between the inorganic part of the ceramic surface and the organic part of the resin repair material. [17]. Some universal adhesives include a silane primer for chemical bonding to silica-based ceramics or methacryloyloxydecyl dihydrogen phosphate for chemical bonding to zirconia-based ceramics without needing an additional primer step. [18] it is useful for intraoral repair of fractured ceramic restorations, especially in difficult clinical situations. It could be assumed that the silane concentration in the adhesive was incompatible with the hydroxyl groups formed on the ceramic surfaces.

Restorations usually fail after ageing in oral environment. The surfaces of restorative materials may change as a result of ageing. As a result, restoration ageing should be taken into account and factored into restoration repair planning [19]. Ceramic materials were originally intended for use in anterior restoration, where aesthetics are the most important consideration. Fractured ceramic restorations are considered an aesthetic emergency and require immediate attention as they cause an aesthetic compromise. Because of their improved mechanical properties, better shade matching, and color stability for long-term aesthetics, composite resin has become the material of choice for ceramic repair procedures. [20] Therefore, the present study is conducted to evaluate the color stability of hybrid ceramic repaired with resin composite before and after aging and staining. The null hypothesis of this study was that no significant difference regarding color stability before and after aging.

Methodology

The specified vita enamic ceramic blocks shade A2 (14*14 mm) were sliced into discs with constant thickness 1mm using a low speed, high precision Isomet diamond saw 4000*. The slices were cut under integrated coolant delivery system that flooded the samples from both sides of the blade while tracking the blade movement. Then ceramic disc thickness was checked using digital caliper. Specimens have been ultrasonically cleaned in distilled water for 5min and then they were aged for one month in a water bath at 37°C for. The water was changed once a week, and the temperature was checked on a regular basis. The samples were embedded inside an acrylic resin mold.

The 16 discs of the material were divided into 2 groups (n = 8) based on different surface treatments. Group A: hybrid ceramic discs have been etched by 9% buffered hydrofluoric acid for 60s and rinsed for 60s with distilled water, then dried with water and oil free air. A thin layer of silane coupling agent was applied to the etched ceramic surface by a micro brush for 1 minute and then dried with gentle air blowing for 5 seconds. Single bond universal adhesive (Scotchbond universal adhesive, 3m) was applied using a micro brush to the etched and silanted surface, then drying was done by gentle air blowing for 5s, followed by curing using a LED light curing unite (3M ESPE Elipar LED curing light) for 20s. Group B: hybrid ceramic discs etched by 9% buffered hydrofluoric acid for one minute and rinsed with distilled water for 1minute, then dried with water –free and oil free air. A thin layer of single bond universal adhesive (Scotchbond universal adhesive, 3m) was applied to the etched surface using micro brush, then drying was done by gentle air blowing for 5s, followed by curing using a LED light curing unite (3M ESPE Elipar LED curing light) for 20s.

For composite repairing, Split Teflon mold was fabricated to ensure a standard thickness of resin composite samples, with an external diameter of 20 mm, an inner dimension 6 mm in diameter and 1 mm in depth. Teflon mold was first placed on the vita enamic sample and then repair resin composite (Amaris) has been packed onto pretreated VE CAD/CAM hybrid ceramic surfaces. Resin composite was dispensed from the syringe on the disc, and then the glass slab was applied with pressure to ensure complete seating and uniform 1 mm thickness of composite created by the mold. Composite was cured for 20 s using a LED light curing unite (3M ESPE Elipar LED curing light). The samples have been subjected to 5000 thermal cycles on a thermal cycler with water baths at 5 c and 55 and dwell times of 30 seconds. The repaired specimens were immersed in coffee solution for 6 days under controlled temperature 37°C simulating 6 months inside oral cavity. The coffee solution was prepared by using 25g of powder for 250ml of water. Samples were subjected to color measurement before repair and after immersion in staining solution.

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* Buehler Isomet diamond saw 4000, Buehler, USA

VTA Easyshade Compact is the device used in color measurements (Model DEASYCHP, VITA Zahnfabrik, Bad Sackingen, Germany). The Vita Easyshade was calibrated using its calibration block before measuring the color of the specimens, as directed by the manufacturer. To obtain accurate measurements, the probe tip was placed perpendicular at the center of each specimen and flushed into the surface of the specimens. The measurements were carried out three times.CIE Lab was used to calculate the color difference between the samples before and after immersion in the staining solution.in this system, color is expressed by three coordinators L*a*b*.

For color difference, calculating the following formula is used:

$$\Delta E = [(L1–L2)\ 2 + (a1–a2)\ 2 + (b1–b2)\ 2]\ ½$$

RESULTS

Numerical data were explored for normality by checking the data distribution, calculating the mean and median values and using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data had a parametric distribution, so mean and standard deviation (SD) values were used to represent it. Intergroup comparisons were analyzed using independent t-test. Pearson correlation coefficient was used to study the correlation between color change and surface treatments. The significance level was set at $p \leq 0.05$ within all tests. Statistical analysis was performed with IBM ® SPSS® Statistics Version 26 for Windows.

The results showed that the color changes of repaired samples in two groups were above the clinically acceptable value ($\Delta E \geq 3.3$) as showed in table (2). Mean and Standard deviation (SD) values for color change (ΔE) of different groups were presented in table (1)

TABLE (1): Mean ± standard deviation (SD) of color change (ΔE) for different groups

Color change (mean±SD)		p-value
Group (A)	Group (B)	
5.88±0.86	4.35±0.83	w0.003*

***; Significant** (*p* **≤ 0.05) ns; non-significant (p>0.05)**

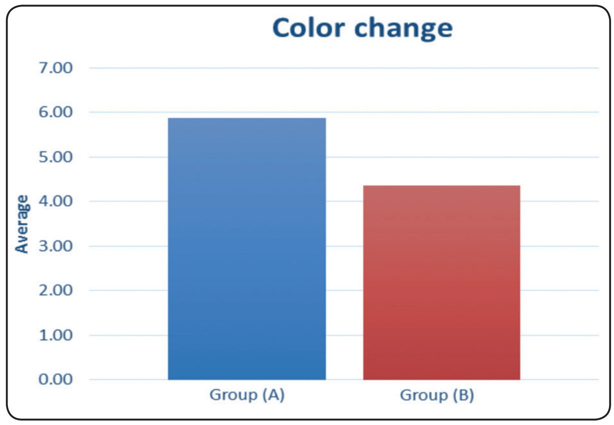

Fig. (1) Bar chart showing average color change (ΔE) of two groups

DISCUSSION

The null hypothesis was rejected as a result of the findings of this study. There was a significant difference in color stability before and after ageing, as well as a significant difference in color stability with various surface treatments. Group (B) which treated with (HF and universal bond) was more color stable than group (A) which treated with (HF, Saline and universal bond) .Color stability of repaired hybrid ceramics still the major problem in restorative dentistry. The real challenge was to find the optimum way for a long lasting repair for these materials.[21] In dentistry, complete replacement of fractured restorations is usually costly and time-consuming. Repair has recently been suggested as a viable treatment option.[22]

For the repair of fractured ceramic restorations, a variety of composite resin systems is available in the market. As the repair composite, a nano hybrid resin composite restorative material was used, which contained nanofillers in addition to the conventional hybrid-type fillers [23]. The main benefits of nanofillers were improved translucency and polishability. The interconnected structure of the hybrid ceramic (vita enamic) material used in this study has a dominant ceramic network with minor composite content.[24] Because composite can be used as a repair material, resin-matrix restorations are easier to repair intraorally than glass ceramics. [25]

In this study two surface treatments were performed group (a) Hydrofluoric acid (Ultradent Porcelain Etch is 9% conc for 60 second) followed by Silane (Ultradent) coupling agent followed by universal bond system. Group (b) Hydrofluoric acid (9%conc for 60 second) followed by Universal bond system. HF etching exposed the hydroxyle group by removing the ceramic part of the polymer infiltrated ceramic. As a result of the HF etching, the surface roughness and undercuts were increased, which is beneficial for micromechanical retention.

In this study using this repair system based on study performed by ***Elsaka et al.*** [2]**,** who found that The bond strength of resin composite to hybrid ceramic was significantly improved by using porcelain etch: 9% hydrofluoric acid, silane coupling agent repair systems .

Hydrofluoric acid etching followed by Silanization is widely recommended to enhance bond strength between resin composite and ceramic. It is reasonable to assume that the quantity of hydroxyl groups exposed on inorganic substrates and the hydrolysable functional groups, which in the silane are in balance. The concentration of the silane solution [16] and the surface pre-treatment protocol, which determine the quantity of hydroxyl groups exposed, determine the strength of the siloxane bond formed.

Thermocycling changed the color coordinates of all tested specimens. Many previous studies have reported a change in the color of repaired dental ceramics as a result of ageing. [19]

The color changes of repaired samples in all groups were above the clinically acceptable value ($\Delta E \geq 3.3$). This may be related to water absorption, coffee solution and microstructure of material. Water sorption is influenced by two major factors: the resin matrix to filler ratio and hydrophilicity of resin matrix. Bisphenolglycidyl methacrylate (Bis-GMA) and Urethane dimethacrylate (UDMA) are the resin matrix formulations of Amaris composite, both of which are hydrophilic molecules that attract water, with Bis-GMA being more hydrophilic than UDMA [26]. It will have a direct effect on the ability to pick up stains from beverages. The greater the resin matrix to filler ratio inside the composite, the more water uptake and later color changes will appear [27].

Previous research revealed that hybrid ceramics containing (UDMA, TEGDMA)TEGDMA had higher discoloration values than other hybrid ceramics, implying that TEGDMA was to blame for the discoloration of hybrid ceramic due to its hydrophilic nature [28]. Water uptake in bis-GMA-based resins was reported to increase from 3 to 6%, whereas TEGDMA only increased from 0 to 1%([28].

Coffee solution is the most chromogenic solution in comparison to other beverages, and it is also one of the most popular beverages in the world. Coffee components like tannin and chromogenic acid have been proven to cause staining, and the pH of coffee, which ranges from 4.9 to 5.2, has been found to accelerate the discoloration process. In this study, a coffee solution has been used as a staining solution for 6 days, simulating approximately 6 months of coffee consumption inside the oral cavity. [29]

This result of present study was in line with **Ibrahim et al. (2019)** [30] who investigated the colour stability of hybrid ceramics (Vita Enamic) and oxide ceramics (Zirconia) and discovered that in Enamic, the ceramic network material is infiltrated with a mixture of urethane dimethacrylates (UDMA) and triethylene glycol dimethacrylates (TEGDMA). Because TEGDMA absorbs more water, staining agents penetrate the resin matrix more easily. As a result, the stainability of Enamic could be attributed to its TEGDMA content.

Also the result of present study is was agreement with **Ertas et al. (2006)**[28] who tested the discoloration of two nanohybrids, two microhybrids, and a posterior composite resin material after immersion in various beverages such as tea, cola, coffee, red wine, and water And observed that their colour change in staining solutions was ranked in the following order water < cola < tea < coffee < red wine. However, because of the effectiveness of each repair protocol varies depending on the material, neither of the individual surface treatments could be suggested as a universally ideal repair protocol. More research is needed to assess the effects of long-term ageing and loading on the repaired hybrid ceramic with composite resin. Furthermore, the clinical performance of repaired ceramic should be assessed in order supply dental practitioners with accurate recommendations.

CONCLUSION

Depending on the results of this study, the following conclusions can be reached:

1- Based on the type of composite used in this study, there was perceptible color change in the repaired samples.

2- Also, using saline coupling agent in surface treatment of fractured restoration improved bond strength, but it has negative impact on color stability of repaired restoration.

RECOMMENDATION

Further studies are recommended to use different types of composite resin as repair material to improve color stability of repaired ceramic restoration.

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