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INFLUENCE OF BLEACHING ON COLOUR AND SURFACE ROUGHNESS, AND MIRCOSHEAR BOND STRENGTH OF REPAIR, FOR NOVEL HYBRID CERAMIC

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ABSTRACT

Objective: This study investigated the effect of bleaching on the colour, surface roughness, and microshear bond strength of repair composite to a hybrid ceramic material, CERASMART.

Methods: This study was conducted in two parts; first effect of bleach on the colour and surface roughness, secondly effect of bleaching on mirco-shear (μSBS) bond strength. 8 Plate specimens of a CAD/CAM hybrid ceramic (CERASMART, GC) were cut using isomet saw (Beuhler, Germany). To assess colour (ΔE) and surface roughness (Ra) (n= 6) were used; and to assess microshear bond strength (μSBS) 18 specimens were prepared; (n=9) composite micro-cylinders were bonded each to an unbleached and bleached CERASMART plate. Colour and surface roughness were evaluated before, and after bleaching. A spectrophotometer was used to assess colour, surface roughness was assessed using a digital microscope at 120X magnification and an image software were analyzed using WSxM software. MicroShear bond strength (μSBS) was tested in a universal testing machine at a crosshead speed of 0.5 mm/min, using orthodontic wire loop (0.014" in diameter) wrapped around the bonded micro-cylinder. Failure modes were investigated with a digital camera at 35X. Data were analyzed with Test with $\alpha = 0.05$.

Results: (ΔE1.54) was more than 1 and less than 2. Mean (Ra) values were [0.2516 ± 0.0024μm] for unbleached, and [0.2511 ± 0.0025μm] for bleached, showing no statistically significant difference between resultant (Ra) values. Mean microshear bond strength (μSBS) values showed [19.6 ± 5.2 MPa] for unbleached, and [20.1 ± 3.7MPa] for bleached, showing no statistically significant difference between resultant (μSBS). Failure modes were predominately mixed (combined adhesive and cohesive in the repair material).

Conclusion: Bleaching did not affect the repair potential of CERASMART material. Colour was affected however, it is not clinically perceptible. Bleaching did not affect surface roughness.

Clinical implications repair can be safely performed on bleached hybrid ceramic, even immediately after bleaching without influencing the bond strength.

KEYWORDS: bleaching, hybrid ceramics, nanofilled composites, PICN, bonding, ceramic and composite repair.

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INTRODUCTION

Esthetics constitute a considerable interest for today's patients, both tooth form and colour. Many factors affect tooth colour whether intrinsic or extrinsic [1]. There are many approaches to improving tooth colour that can be as simple as whitening tooth pastes or professional at the dentist's office such as scaling, professional bleaching, crowns and veneers[2-4].

External bleaching is a common practice among patients; available systems are off over-the-counter products, dentist supervised night bleaching, or in-office [5,6]. The main concerns of bleaching are the bleaching agent concentration, application time, product application mode such as gels in trays, strips films, or paint-on and light activation [7,8]. The most popular bleaching agents are hydrogen peroxide and carbamide peroxide [9]. Hydrogen peroxide (H_2O_2) is a powerful bleaching agent that rapidly penetrates tooth enamel lifting stains. The gel type, carbamide peroxide versus hydrogen peroxide, plus the gel concentration determine effectiveness, the potential for irritation or tooth sensitivity, longevity of results, and its frequency of use [10].

Advances in computer-aided design/computer-aided manufacturing (CAD/CAM) in the fabrication of indirect dental restorations have changed the face of dentistry in the restoration manufacture and materials development for use in CAD/CAM applications. Materials suitable for CAD/CAM processing is a fast growing and changing field in dentistry and currently witnessing a lot of research and production [11].

Chairside CAD/CAM is gaining rapid acceptance[12]. Currently, two main types of esthetic materials are available for CAD/ CAM-processed indirect dental restorations. They are either ceramics (polycrystalline and glass ceramics) or improved modified resin-composites be that macro-, micro-, hybrid-filled or nano-composites[13]. Resin composites consist of a polymeric matrix reinforced by fillers that could be inorganic (ceramics or glass-ceramics or glasses), organic, or composite[14]. Resin-composite materials are claimed to offer significant advantages related to their machinability and intra-oral reparability of function generated defects [11,13].

Development of resin-based materials for CAD/CAM applications is quite recent. During the past few years new resin based options of materials have appeared; a heavily particle filled resin that is cured during its factory manufacture at higher temperature/pressure and a ceramic based resin interpenetrating network (IPN) material. The latter is also named polymer infiltrated ceramic material PICN [13].

From a historical aspect first appearance was Paradigm MZ100 (3M ESPE), produced by temperature and pressure treatment of its successful predecessor direct restorative Z100 composite resin [15]. Lava Ultimate (3M ESPE), also produced by temperature and pressure treatment, was introduced to replace Paradigm MZ100. Both Paradigm MZ100 (85% zirconia-silica ceramic by weight) and Lava Ultimate (80% silica and zirconia nanoparticles and nanoclusters by weight) are obtained by the classic incorporation of filler particles into a monomer mixture [11]. Vita Enamic (VITA Zahnfabrik, Bad Säckingen, Germany) was introduced in the early 2013. It is a polymer-infiltrated ceramic network material, contains 86% (by weight) porous feldspathic ceramic matrix and infiltrated with a copolymer (urethane dimethacrylate and triethylene glycol dimethacrylate) [13]. Most recent introduction is CERASMART (GC Dental Products); an IPN material and a high density composite material 71% silica and barium glass nanoparticles by weight [16]. Interest is rising in using interpenetrating network (IPN) material, as their structure improves load distribution, they are also claimed to show less susceptibility to chipping during the milling[17].

Instead of total restoration replacement, advances in adhesive dentistry using resin bonded composite made intraoral repair a convenient and functional alternative [18,19]. Many repair protocols are described in literature [20-25], they are based on modifying the surface to be repaired enhancing its adhesive bonding capacity with the repair composite resin material. Repair protocols include mechanical, chemical, or physico-mechanical methods; mechanical method include burs or airborne particle abrasion with alumina oxide particles [20, 21] for chemical surface modification orthophosphoric or hydrofluoric acid (HF) etching is utilized [21,23], while tribosilica coating is used as a physico-mechanical surface modification [24]. Resin composite is used for rebuilding chipped or missing part; repair composites share similar mechanical and optical with resin-composite crowns, while with ceramic crowns they are of different mechanical and optical properties [26].

Concerning the impact of bleaching materials and techniques; bleaching is a well recognized practice, whether performed professionally at the dentist office or carried out by the patient alone at home with or without dentist supervision. restorative materials maybe variably influenced namely their colour and microhardness [27-41].

The purpose of this study is to evaluate the effect of bleaching on colour and surface roughness, as well as effect of bleaching on mirco-shear (μSBS) bond strength of repaired PICN restorations. The hypothesis of the present investigation is that bleaching will affect microshear bond strength, colour and roughness.

MATERIALS AND METHODS

Based upon the results of Zaghloul H et al, 2014[42], using alpha (α) level of 0.05 (5%) and Beta (β) level of 0.20 (20%) i.e. power = 80%; the minimum estimated sample size was 5 specimens per group for a total of 10 specimens. Sample size calculation was performed using IBM® SPSS® Sample Power® Release 3.0.1

The effect of bleaching on CERASMART was evaluated. This study was conducted in two parts; the first part concerned evaluating the effect of bleach on the colour and surface roughness of CERASMART, while the second part concerned assessing the effect of the effect of bleaching on mirco-shear (μSBS) bond strength.

The materials, manufacturers, composition and batch numbers are listed in Table 1. CERASMART blocks shade A2 HT 14 were used (GC Dental Products Corp. Japan). Specimens were prepared using automatic diamond section saw (Isomet Buehler 4000, Germany), where an 8” diameter diamond blade was used to section the CERASMART block into plate shaped specimens of 1.5 mm thickness. This thickness was selected

TABLE (1) Materials, Manufacturers, Composition

Materials	Manufacturers	Composition
CERASMART blocks	GC Corp., Tokyo, Japan	Flexible nano ceramic matrix with an even distribution of nano ceramic filler
Beaming white 38% H_2O_2	Beaming white; Vancouver, USA	In-office Hydrogen peroxide 38%
Ceramic primer; Silane	Pentron Clinical	Pre-hydrolyzed silane coupling agent; Organosilane in methyl alcohol
Bonding agent; Optibond solo pluS	KERR, USA	Total-etch, single-component dental Ethanol-based adhesive, 15% filled with 0.4μm barium glass filler.
Herculite XRV ultra flow, Shade A3.	KERR, USA	Nanohybrid Flowable Composite

based on the manufacturer's recommendations to the thickness of restoration being not less than 1.5 mm [43]. Thickness was measured with a digital caliper, accepted thickness values were 1.5±0.01 mm.

A total of 8 CERASMART plates were cut; they were divided into two sets; (n= 6) to assess colour and surface roughness, and (n=2; one unbleached plate and one bleached) to assess microshear bond strength (μSBS), a total of 18 specimens of composite micro-cylinders were prepared; (n=9) bonded to each of the unbleached and bleached CERASMART plate. Total specimens prepared for this study were 24.

Colour evaluation Colour was assessed before and after bleaching; specimens were placed in spectrophotometer (Agilent Cary 5000, conforms to CIE recommendations) by measuring the ratio of the light reflected from a specimen to that reflected from a reference (white & black) across the visible spectrum at intervals of 1, 5, 10, or 20 nm. ΔE was measured against a black background.

Colour parameters of each specimen were calculated and expressed in terms of three coordinate values (L*, a*, b*) established by international colour space CIE-Lab (Commission International de l'Eclairage L*a*b*). (L*, a*, b*) of each specimen and colour difference (ΔE) before and after aging (AAA) and calculated by the following formulae[44-46]

$$C^*ab= [(a^*)^2 + (b^*)^2]^{1/2}$$

$$\Delta E= [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Δ L*, Δ a*, and Δ b* represent the difference in CIE colour-space parameters of the two colours. Delta E (ΔE) of 3.7 or less was considered clinically acceptable in the study.

Bleaching. An In-office Hydrogen peroxide 38% (Beaming white; Beaming white, Vancouver, USA) was used. Bleaching was carried out according to the manufacturer's instruction regarding application mode and time. The material is provided as a gel in two separate syringes; Hydrogen peroxide and the activator. They were mixed together as instructed and uniformly applied to the specimen surface using a microbrush. The gel was left on the specimen surface for 15 minutes, then removed with a cotton swab. The process was repeated two more times in the same manner, making a total of 3 applications. After the final application the specimen were thoroughly rinsed.

Surface roughness was evaluated for unbleached and bleached specimens, they were photographed using USB Digital microscope with a built-in camera *(Scope Capture Digital Microscope, Guangdong, China)* connected to an IBM compatible personal computer using a fixed magnification of 120X. The images were recorded with a resolution of 1280 × 1024 pixels per image. Digital microscope images were cropped to 350 x 400 pixels using Microsoft office picture manager to specify/standardize area of roughness measurement. The cropped images were analyzed using WSxM software *(Ver 5 develop 4.1, Nanotec, Electronica, SL)*. Within the WSxM software, all limits, sizes, frames and measured parameters are expressed in pixels. Therefore, system calibration was done to convert the pixels into absolute real world units. Calibration was made by comparing an object of known size (a ruler in this study) with a scale generated by the software. WSxM software was used to calculate average of heights (R_a) expressed in µm , which can be assumed as a reliable indices of surface roughness [47].

Microshear bond strength (μSBS). CERASMART manufacturer's recommendation for repair was followed for surface preparation and application of the repair composite. The surface of the CERASMART plates unbleached and bleached were roughened using a diamond point (Dentsply). Ceramic primer (Silane; Pentron Clinical) was applied for 1 minute then dried with gentle air pressure. Bonding agent (Optibond solo plus; KERR, USA) was applied and light cured for 10s using Elipar S10 light curing unit at an intensity of 1200 mw/cm^2. For repair manufacturer recommends using flowable composite of the same nano-ceramic technology as CERASMART, Herculite XRV ultra flow shade A3 (Nanohybrid Flowable Composite; KERR, USA) was used.

Small transparent microtubules were cut from polyvinyl tube with internal diameter of 0.9 mm and a height of 1mm. Nine (n=9) microtubules were mounted and bonded over each plate specimen; unbleached and bleached, prior to injecting the repair composite.

Composite Mico-cylinders were prepared by injecting the repair flowable composite into the polyvinyl tubules. A celluloid strip was placed over the micro-tubes before curing and the composite resin was cured for 20 seconds at zero distance to ensure absence of any oxygen inhibited layers using Elipar S10 curing unit. After curing polyvinyl micro-tube were split using the bard barker blade and a sharp explorer was placed between the micro-tubule and the composite cylinder separating them from each other. (fig. 1).

This procedure was carried out for the bleached CERASMART plate immediately after bleaching, no waiting time was given

Microshear bond testing: (fig. 1).

This test was performed using NEXYGEN from Lloyd Instruments. Each specimen with its own bonded composite micro-cylinders was secured with tightening screws to the lower fixed compartment of a materials testing machine (Model LRX-plus; Lloyd Instruments Ltd., Fareham, UK) with a loadcell of 5 kN and data were recorded using computer software (Nexygen-MT, Lloyd Instruments Ltd., Fareham, UK). A loop prepared from an orthodontic wire (0.014” in diameter) was wrapped around the bonded micro-cylinder assembly as close as possible to the base of the micro cylinder and aligned with the loading axis of the upper movable compartment of the testing

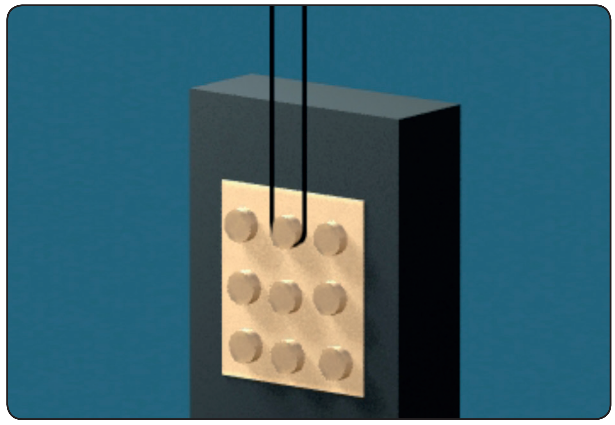

Fig. (1)

machine. A shearing load with tensile mode of force was applied via materials testing machine at a crosshead speed of 0.5 mm/min. The relatively slow crosshead speed was selected in order to produce a shearing force that resulted in debonding of the micro cylinder along the substrate-adhesive interface. The load required to cause debonding was recorded in Newton.

Micro-Shear bond strength calculation;

- The load at failure was divided by bonding area to express the bond strength in MPa :

  $\tau = P/\pi r^2$; where ; τ =bond strength (in MPa), P =load at failure (in N), π =3.14, r = radius of micro-cylinder (in mm)

- The load-deflection curves were recorded using computer software (Nexygen-MT Lloyd Instruments)

Evaluation of debonded ceramic surfaces. After microshear bond strength test, all specimens were viewed using a USB digital microscope USB Digital microscope with a built-in camera *(Scope Capture Digital Microscope, Guangdong, China)* using a magnification of 35X. The images were captured and transferred to an IBM personal computer equipped with the image-tool software (Image J.1.34u-National Institue of Health, USA) to determine the failure interface. Failure modes

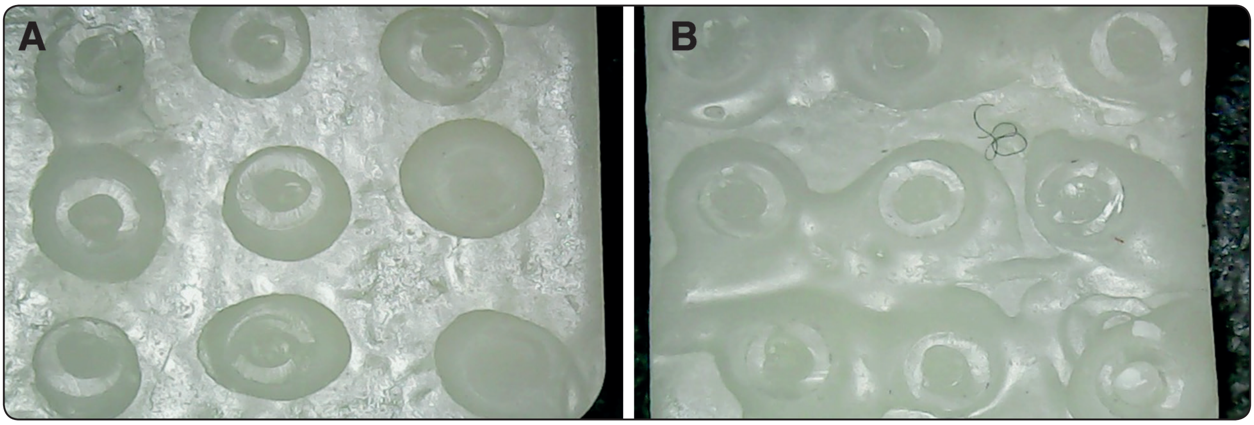

Fig. (2) Failure mode : (A) microcylinders bonded to unbleached Cerasmart. (B) microcylinders bonded to bleached Cerasmart

were calculated in percentage (%), and categorized as adhesive at the resin/ceramic interface, cohesive within the repair resin or within the substrate, and mixed adhesive/cohesive failure.

Statistical Analysis

Numerical data were explored for normality by checking the data distribution and using Kolmogorov-Smirnov and Shapiro-Wilk tests. All data showed parametric distribution. Data were represented as mean, standard deviation (SD), median, range and 95% Confidence interval (95% CI) values.

Paired t-test was used to compare between bleached and non-bleached specimens as well as to study the changes in color parameters after bleaching.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM (IBM Corporation, NY, USA), SPSS (SPSS, Inc., an IBM Company) Statistics Version 20 for Windows.

Failure mode data (Qualitative data) were presented as frequencies and percentages. Fisher's Exact test was used to compare between failure modes of the two groups.

RESULTS

Color parameters

There was a statistically significant increase in mean (L*) value after bleaching at P=0.004. There was no statistically significant change in mean (a*) at P=0.741 as well as (b*) values at P=0.493 after bleaching. (ΔE) at 1.54.

Bleaching did not bring about any statistically significant change in color, however it did significantly change L* value into becoming lighter, which is still at a clinically accepted value. Table (2), Fig (3,4,5).

Surface roughness (Ra)

Results obtained for Surface roughness (Ra) showed mean [$0.2516 \pm 0.0024\mu m$] for unbleached, and mean [$0.2511 \pm 0.0025\mu m$] for bleached. There was no statistically significant difference between Ra values at P=0.650. However it seemed to decrease. Table (3), Fig (6&7).

Micro-shear bond strength

Results obtained for microshear bond strength (μSBS) showed mean [19.6±5.2 MPa] for unbleached, and mean [20.1 ±3.7MPa] for bleached. There was no statistically significant difference between micro-shear bond strengths at P= 0.826 Table(4), fig(8).

TABLE (2) Descriptive statistics and results of comparison between color parameters of the two groups

Parameter	Bleaching	Mean	SD	Median	Minimum	Maximum	95% CI		*P*-value
							Lower bound	Upper bound	
L*	Not bleached	75.33	0.18	75.35	75.10	75.60	75.15	75.52	0.004*
	Bleached	76.17	0.37	76.10	75.70	76.60	75.78	76.56	
a*	Not bleached	1.17	0.21	1.20	0.80	1.40	0.95	1.38	0.741
	Bleached	1.22	0.42	1.20	0.60	1.90	0.78	1.65	
b*	Not bleached	16.50	0.64	16.60	15.60	17.20	15.83	17.17	0.493
	Bleached	16.02	1.18	16.35	13.80	17.20	14.78	17.26	
Color change (ΔE)		***1.54***	1.06	1.19	0.64	3.56	0.42	2.65	

**: Significant at* $P \le 0.05$

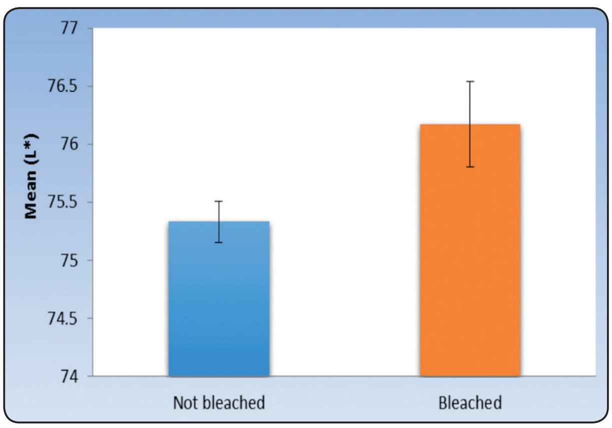

Fig. (3) Mean and standard deviation values of (L*) in the two groups

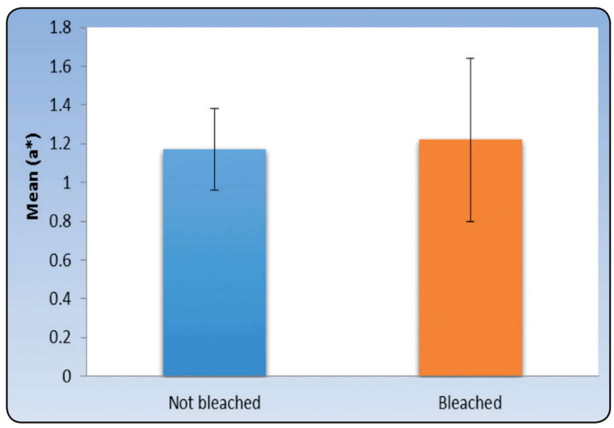

Fig.(4) Mean and standard deviation values of (a*) in the two groups

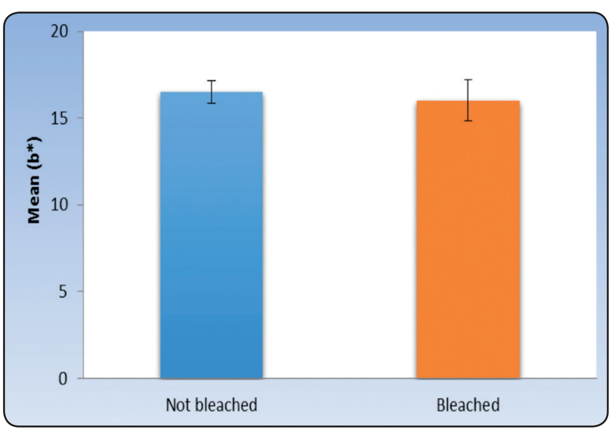

Fig (5) Mean and standard deviation values of (b*) in the two groups

Failure mode of debonded surface:

There was no statistically significant difference between failure modes in the two groups. Majority appears to be mixed failure mode in the repair material in both unbleached and bleached, followed by cohesive mode. Table(5), fig(9).

TABLE (3) Descriptive statistics and results of comparison between (Ra) (μm) values of the two groups

Group	Mean	SD	Median	Minimum	Maximum	95% CI		*P*-value
						Lower bound	Upper bound	
Not bleached	0.2516	0.0024	0.2506	0.2495	0.2573	0.2498	0.2535	0.650
Bleached	0.2511	0.0025	0.2506	0.2483	0.2560	0.2492	0.2530	

***: Significant at P ≤ 0.05**

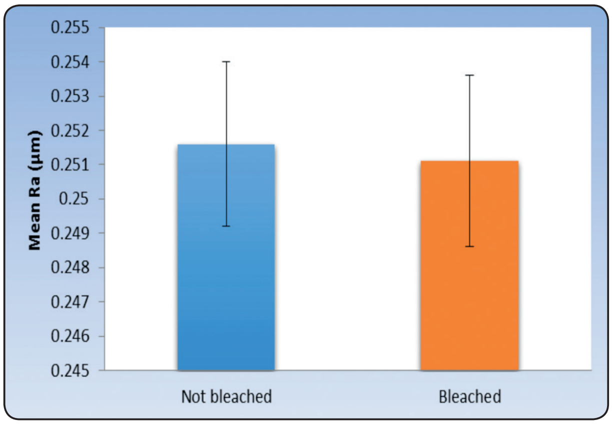

Fig. (6) Mean and standard deviation values of Ra of the two groups in μm

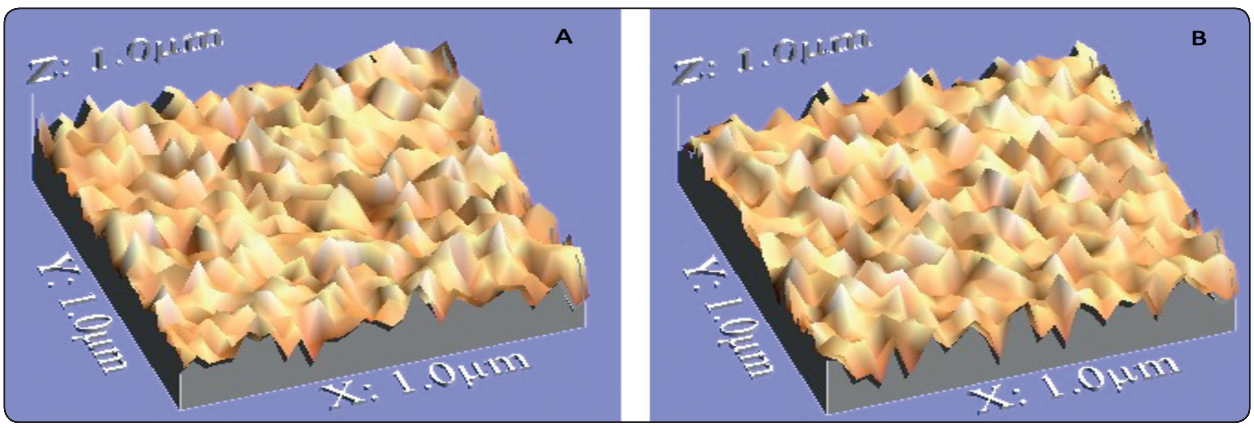

Fig. (7) Surface roughness peaks and valleys. (A) Unbleached. (B) Bleached. Peaks and valleys appear more and closely packed in the unbleached state, while in the bleached they appear more spaced and peaks are of lesser high and number.

TABLE (4) Descriptive statistics and results of comparison between micro-shear bond strength (MPa):

Group	Mean	SD	Median	Minimum	Maximum	95% CI		*P*-value
						Lower bound	Upper bound	
Not bleached	19.6	5.2	19.3	12.7	31.4	15.7	23.6	0.826
Bleached	20.1	3.7	19.8	15.7	25.9	17.2	23.0	

***: Significant at P ≤ 0.05**

TABLE (5) The frequencies (n), percentages (%) and results of Fisher's Exact test for the comparison between failure modes of the two groups

Failure mode	Not Bleached (n =9)		Bleached (n =9)		P-value
	n	%	n	%	
Adhesive	2	22.2	0	0.0	0.534
Cohesive	3	33.3	3	33.3	
Mixed	4	44.4	6	66.7	

: Significant at $P \leq 0.05$

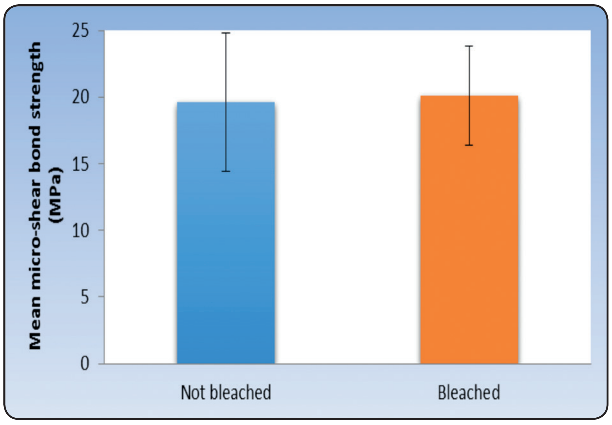

Fig. (8) Mean and standard deviation values of micro-shear bond strengths of the two groups in MPa

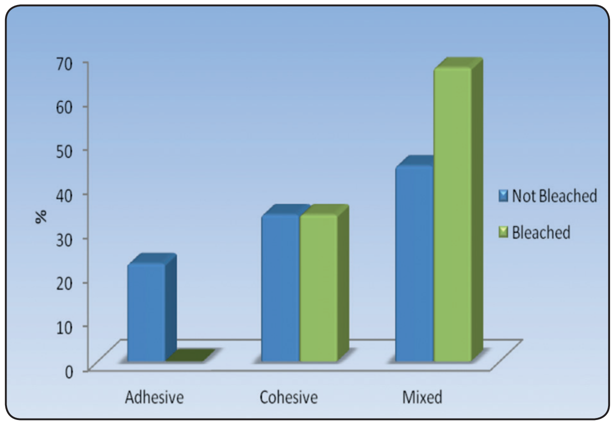

Fig. (9) Bar chart representing failure modes in the two groups

DISCUSSION

CERASMART an IPN material, is a high density composite material composed of 71% silica and barium glass nanoparticles by weight. According to the manufacturer it is classified as a flexible hybrid nanoceramic.

Bleaching is a common minimally invasive method to achieve esthetic outcomes; it is a well-recognized practice among patients; whether professionally by the dentist or at home. During bleaching, natural teeth as well as restorations are treated [48,49]. Therefore being familiar with the effects of bleaching on bonding, colour, and surface roughness is important. Repairing fractured restorations is not uncommon in daily practice therefore a durable bond between the restoration and the repair composite is critical.

With the advent of adhesive dentistry repair of fractured restorations comes at ease and of lower cost compared to total replacement [50,51], also avoiding the need to sacrifice more sound tooth preparation [52].

Considering the effect of bleaching on dental restorative materials; some authors have demonstrated that bleaching induces change in properties such as color, surface and subsurface microhardness, and surface roughness [9,53,54]. In contrast, there are findings that report that bleaching effect are clinically insignificant [9].

Bleaching materials available are either hydrogen peroxide (HP) or carbamide peroxide (CP). On contact with tissues and saliva, CP immediately breaks down into about one-third HP and two-thirds urea. HP is highly reactive demonstrating a high capacity for oxidation and reduction to generate free radicals [1,55], it also demonstrates ability for diffusion [56].

This study aimed to investigate the effect of an inoffice bleaching system on novel hybrid ceramic CERASMART regarding mircoshear bond strength (***µSBS***) of its repair, colour and surface roughness. The bleaching system used in this study was applied following the manufacturer's instructions for use in clinic.

The hypothesis of the present investigation is that bleaching will affect colour and surface roughness, and the second is that microshear bond strength will be affected.

According to the results the first hypothesis was accepted as (L*) parameter of colour was significantly affected, however surface roughness was not affected. The second hypothesis was rejected as bleaching had not affected the microshear bond strength (***µSBS***).

µSBS test is a relatively simple test that permits efficient screening of adhesive systems, also its specimens are easily constructed[57].

This study investigated the repair potential novel CERASMART. The results obtained mean (***µSBS***) [19.6±5.2 MPa] for unbleached, and [20.1±3.7MPa] for bleached with no statistically significant difference between (***µSBS***) the two groups. The results indicate that bleaching does not affect bonding and repair can be safely achieved on bleached restorations made of CERASMART. These results are concordant with results of authors who tested repair potential of CAD/CAM resin blocks roughened with diamond bur and treated with siliane coupling agent before repair; wahsh and ghallab tested Lava ultimate and showed (12.6±6MPa), while Zaghloul et al [42] tested CAD/CAM composite and showed (15.85±5.29 MPa). Authors of both research groups had studied different surface treatments without bleaching.

In the current study same protocol of diamond bur roughening and silane coupling agent was followed prior to bond and repair composite application for both unbleached and bleached samples. In fact this is the protocol the manufacturer (*GC Dental Products*) recommends for repair.

Silanes improve the wetting of the surface by the bonding agent, allowing bonding agent to easily infiltrate into the irregularities created by the surface roughening rendering the silane-coated composite surface more reactive [58-60].

Surface roughness (Ra) refers to the finer irregularities of the surface that usually result from the action of the production process or material condition and is measured in micrometers (µm) [61]. The outcomes of the surface roughness test in the present study indicated that the surface roughness (R_a) was not shown to vary significantly as affected by bleaching. [0.2516± 0.0024 µm] for unbleached, and [0.2511± 0.0025 µm] for bleached, also the surface photographed analysed show that peak and valley distribution appear more spaced after bleaching supporting the (Ra) readings . The results of this study show concordance with those of Atali and Topbasi [6], who demonstrated that nano-hybrid composites displayed the least (Ra) on studying the effect of different bleaching methods on composite. They showed that nano super filled composites and nano hybrid composites showed similar surface roughness,

After bleaching Composite roughness values may be associated with different polymers in their organic matrix, the filler content and particle size [62,63], effect of bleaching on the surface texture is material- and time-dependent [64].

Resin interpenetrating network (IPN) material are multi-phase structures of mutually continuous and interconnected phases [65]. IPN materials have a three dimensional geometry [13] which differs from traditional composites, such as discrete fiber or particle reinforced and laminated composites. The purpose of developing synthetic IPNs is driven by the attempt to enhance or tailor the physical properties of the constituent phases, e.g. fracture toughness [66] fracture strength [67], contact and grinding damage tolerance [68]. Compared to conventional composites, in which only the matrix phase is continuous, IPNs exhibit some physical properties that are different and often superior. According to Feng et al [69] the IPN reinforcing phase allows effective stress distribution. As it is IPN it exhibits insufficient space for bleaching agent to penetrate and changes it affecting the bond strength.

According to some authors [70] using composite resins immediately after bleaching is still controversial, however the results obtained for both unbleached and bleached CERASMART are comparable.

Increase in mean (L*) value after bleaching denotes specimens become brighter. When ΔE shows less than one unit ($\Delta E<1$), colours are judged to match, ΔE values 2-2.6 can be perceptible, ΔE 2.6 and above colours are perceived as different [71,72] ΔE change in this study is 1.54 indicating it is more than 1 and less than 2 rendering it not perceptible nor will it require changing the restoration, these results fall in agreement with costa et al [73].

On observing the failure mode mixed mode predominates in both unbleached and bleached, followed by cohesive mode, adhesive mode amounted to the least in the unbleached at 22.22% and none for the bleached. The predominance of mixed mode of failure could be attributed to diamond roughening of the surface before repair as well as salinization. For the bleached mixed mode is at 66.67% compared to that of the unbleached at 44.44% this could be attributed to possibility of surface roughness alteration by bleaching, and that hydrogen peroxide may have exhibited more penetration action on restorative material as it acts in enamel.

Mixed and cohesive failure modes indicate a strong bond. While adhesive failure mode indicates a weak bond since it is at the interface or joint.

In Regard to the imitations of this study; effect of other in-office and at home bleaching products, concentration and application times, aging and using surface sealant glaze material on bond strength, also effect of bleaching on different shades of CERASMART, and delayed repair after bleaching, should be tested

CONCLUSIONS

Under the condition of the present study the following is evident; Bleaching did not affect bond strength, therefore bleached restorations can safely be repaired, even if immediately after bleaching, provided that surface enhancement is carried out by bur roughening, salinization, and bonding.

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