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Fracture strength and color stability of direct composite veneer using different materials

"Mohammed Hamoudi Alsunboli B.D.S HDD M.SC " Assistant lecture at College of Dentistry, AL-BAYAN University, Baghdad, Iraq , conservative department

E-mail: m.hamoudi@albayan.edu.iq phone: 07901641590

"Haider Hasan Jasim M.Sc " Assistant professor at college of dentistry , Al.Mustansiria University , Baghdad, Iraq, conservative department

E-mail : denhaider5@gmail.com phone: 07709613641

Abstract

Aim: The purpose of this study was to compare the fracture resistance and color stability of three different restoration materials: Nano composite, flowable composite, and Nanohybid composite.

Materials and Methods: 45 removed human maxillary premolar teeth for orthodontic treatment were chosen. The teeth were divided into three experimental groups, each consisting of fifteen teeth: Direct composite veneers constructed of Nano - composites were employed to fix the teeth in Group A. (Z350 XT, 3M, USA). Group B: Flowable composite was used to directly veneer teeth (G-aenial Universal flo GC, Japan). Group C: Direct composite veneers made of Nanohybid composite were used to reconstruct teeth (G-aenial GC, Japan). Each tooth in groups A, B, and C had a copyplast template made prior to preparation using a 1 mm thick vacuum-pressed polyethylene plastic template. Standard preparations (intra enamel) were made for all teeth in experimental groups using ceramic veneer set burs. By injecting flowable composite via a hole formed in a copyplast template, Group B is restored. In Groups A and C, the buccal third (Bucco-palatally) of the template was filled with restorative material using a plastic tool before being positioned on the tooth and squeezed until it made contact with the unprepared tooth surface. All specimens' baseline colors were assessed using a spectrophotometer (Vita Easyshade, Ivoclar VivadentAG, Schaan, Liechtenstin). After baseline color measurement, each group of laminate veneers were subjected to immersion solutions (Tea bags, Lipton). Each specimen's color values were once again measured with the same spectrophotometer, and the color change values (ΔE) were computed. Using a universal testing equipment, the fracture strength was evaluated.

Results: The ANOVA test showed significant differences in color stability between the test groups (p 0.001). LSD demonstrated a substantial difference between Groups C and A. Likewise, there was a significant difference between Groups C and B (p0.001), but not between Groups A and B (p>0.05). When it came to the mechanical testing, the ANOVA test showed a significant difference in the groups' fracture strengths (p 0.001). The LSD test found a non-significant difference between Group B and C (p>0.05), but a significant difference between Group A and C, Group B and C, and Group C and Group B (p0.001).

Conclusion: All types of composite materials used for veneers in the premolar region for patients with typical biting force may be regarded as safe. Nano-hybrid composite, which was used to rebuild teeth, has the best characteristics in terms of color stability and fracture strength, followed by flowable composite.

Key words: Direct veneer and composite veneer. Color stability, fracture resistance

INTRODUCTION

A composite veneer is one of the techniques for reestablishing the bio-aesthetic relationship. Fracture or de-bonding is the most frequent failure mode connected with laminated veneers in terms of inadequacy. Fractures accounted for 67% of all repair failures after fifteen years of clinical performance. Additionally, it has been shown that factors such as laminate veneer material, preparation design, mechanical thermal cycling, and tooth position affect how quickly laminate veneers break, even if its long-term performance is mostly controlled by the amount and direction of the load. (5) There was no evidence to support the claim that indirect laminates are superior to direct laminates. Direct composite laminate veneers for the treatment of both anterior and posterior teeth offer exceptional esthetic potential and adequate lifespan at a significantly lower cost than analogous ceramic restorations. They may be applied in a single session and are less expensive than indirect solutions. (59) Ceramics are still the preferred esthetic alternative for many physicians, but they still have a limited lifespan due to their susceptibility to staining, wear, and surrounding cracks, which reduces the esthetical outcome over time. (23)

Composite restorations have increasingly being used in dentistry for both anterior and posterior restorative treatment, therefore, dental composite materials should have many requirements that meet the clinical setting. Anterior composite restorations must have the same optical qualities as natural teeth, including color, metamerism, opalescence, and fluorescence, in order to satisfy both the dentist and the patient's aesthetic needs. (20) Several studies have been conducted to evaluate the color stability of composite restorations because composite resins might change color over time. (51) When exposed to different media, such as tea, coffee, coca-cola, chlorohexidine, or bleaching agent, discoloration may develop over time.. There are both intrinsic and extrinsic causes that might cause composite restorations to stain. Extrinsic aspects entail adsorption or absorption of stains from the mouth cavity, whereas intrinsic factors include differences within the substance itself. One of the issues that affects extrinsic staining is the restoration's softness on the surface. (51) Additionally, it has been demonstrated that the brand and color of the restorative material, exposure time, the intensity of various food consumption, and finishing processes all affect color stability. (52)

Colorimeters and spectrophotometers have become commonplace for detecting color changes because color stability was one of the requirements for aesthetic materials. (47**)**Several research revealed that tea has the highest rate of color stability alterations (`17) Various studies have shown that coffee has the biggest influence on color changes. (18)

The aim is to compare the fracture resistance and colour stability of direct veneer restored with three different composite materials, Nanofill composite (Z350 XT, 3M, USA), Nanohybrid composite (G-aenial anterior, GC, Japan), and flowable composite (G-anial universal Flo GC , Japan).

MATERIALS AND METHODS

A total of 45 healthy human first premolars from the maxilla that had been removed for orthodontic treatment were chosen. These teeth had normal occlusal anatomy without attrition, comparable crown dimensions, (7-8 mm; mesio-distally and 8.5-10 mm occluso-cervically). All teeth were visually inspected with blue light transillumination to make sure the enamel was free of cracks, and those that did not were not included in the study. The teeth then placed in 0.1% thymol solution for 48 hour (30). The teeth were mounted into customized rubber mold (25 mm height × 20 mm × 20 mm) using cold cure acrylic (Vertex, Netherlands). The long axis of the tooth is set to be parallel to the center of the mold with the aid of the analyzing rod of the dental surveyor (Jelenko Dental Surveyor, Dentarium, Germany). Three experimental groups were randomly assigned to three sets of teeth. (n=15 sample each) to receive direct composite veneer using one of the following materials: Group A: were Nano composite (Z350 XT, 3M, USA). Group B: flowable composite (G-aenial Universal flo GC, Japan). Group C: Nanohybrid Composite (G-aenial GC, Japan).

In all test groups, a clear copyplastic 1 mm template was created for each tooth independently utilizing a vacuum forming machine (code 132, Biostar, Germany) and a 1 mm thick vacuum pressed polyethylene plastic template. The template was then taken out, and the extra plastic was cut using a medical blade and pair of scissors to create a coping for the buccal and occlusal surfaces of each tooth. (40). The cutting in Groups A and C adheres to the veneer design by 1 mm, which was painted before being used as a stopper during the insertion of the composite. The template is then placed into the tooth, and the template's edge is painted blue to serve as a guide while placing the composite (Fig.2). In group B, a hole was cut in the template occlusally at the cusp tip to enable the extrusion of extra composite materials (Fig. 1) (40) Before each tooth was prepared, a sectional index was made using a putty polyvinylsiloxane substance (Prontosil, Italy) to assess the consistency of tooth reduction. This sectional index may be formed over the original tooth. Using a surgical blade, the index was divided from the Bucco-palatal direction for use in preparatory steps later on 28). Before beginning, a waterproof color marker was used to paint the preparation's outline (Fig.3). Utilizing veneer system preparation burs, uniform preparations (partial wrap) were made for all the teeth (CVS for porcelain veneers, Komet, Germany). In comparison to the middle and occlusal thirds, the cervical third of the face shrank by 0.4 mm and 0.5 mm, respectively. (12) The preparation was completed 1 mm occlusal to the junction of the cement and enamel (24). 1.5 mm Bucco-palatally and 1.5 mm occlusion-cervically were removed from the buccal cusp. (53) Final veneer preparation shown in (Fig.4). The preparation checked with previously made silicon index to determine amount of tooth reduction (Fig.5). However, Some dentin was frequently exposed, especially in the cervical tooth region. After testing the copyplast template on the teeth, fluoride-free pumice was used to polish the prepared tooth. In Byaccordance with the manufacturer's recommendations, the prepared tooth surface was then etched for 15 seconds using 35% phosphoric acid (ScotchbondTM Etchant, 3M ESPE, USA), rinsed for 10 seconds, and gently air dried for 5 seconds. A fully saturated brush was used to apply two successive coats of adhesive (AdperTM ScotchbondTM 1 XT, 3M ESPE, USA) after drying. The adhesive was gently air-thinned for five seconds to allow for evaporation before being light-cured for ten seconds using an LED curing light (D-LIGHT DUO, Switzerland), as directed by the manufacturer. (1) In both B and C groups, following the checking of the copyplast template on the tooth, The customized template was then placed on the tooth and forced down until it made contact with the unprepared tooth surface in the buccal third (Bucco-palatally) using a plastic instrument. (Fig.6,7) The margin of the template should fit to blue line that was previously traced. This would give an indication that the template was set in the correct position. In Group (B), after checking each copyplast template on the tooth, the flowable composite was first injected into the prepared tooth through a tiny aperture on top of each template. Until the flowable composite was completely used up in the template, this process was repeated. (Fig.8) The clear resin matrix was used to cure the resin composite for 40 seconds before the template was removed. (Fig,9) The extra polymerized resin composite was then eliminated using blade number 12 and a diamond finishing burs. A 30-fluted tapered finishing bur was used to remove the incisal composite sprue, and a tapered finishing diamond was used to smooth up the tooth-resin composite interface. A tapered finishing diamond and finishing strips were used to smooth the proximal surfaces and curves. In group B, the surplus composite that had been extruded from the hole was removed, and the composite was then light-cured for 20 seconds using an LED curing lamp. Close to the tooth on both the buccal and occlusal sides was the curative device. (1) All the specimens were stored in a distilled water for 24 hours in an incubator (Future Tech. Digital incubator, f120, China) at 37˚C.. The baseline measurement of veneer color was done in the same lightening conditions using the spectrophotometer (Vita Easyshade, Ivoclar VivadentAG, Schaan, Liechtenstin) **(**38**)**. The central region of the laminate veneer, which is determined by the meeting point of four marks traced, was selected for the Vita Easy shade probe tip placement. (Fig.10). This was to put tip in the same center position before and after aging during the measuring procedure.

The spectrophotometer was recalibrated after color data collection of each sample. Each set of laminate veneers was subjected to tea immersion solutions, which were created by soaking a tea bag (Lipton, UAE) in 200 ml of boiling distilled water for one minute. The probe tip of the calibration part was firmly inserted into it, and it was kept there until a beep signaled that calibration was complete. The immersions were carried out twice daily for ten minutes at room temperature for thirty days. After each immersion process, the veneers were washed with distilled water and then stored in artificial saliva at room temperature in the intervals between the cycles. The immersion solutions were renewed after each application. The samples then were rinsed with distilled water for five minutes and blotted dry with absorbent tissue paper before the final color measurements. The same spectrophotometer was used to measure the color values of each specimen again, and the color change values (E) were calculated using the equation below. (49):

ΔE= [(ΔL*)2+(Δa*)2+(Δb*)2]1/2. L

Lightness is denoted by *, and green-red by a*. and b* for blue-yellow. ΔL*, Δa*, Δb*

compare to the variations between the before- and after-immersion cycles. For each specimen, each color measurement was made three times, and the average of the three readings was computed. The same operator performed each color measurement technique. (49) in order to simulate the oral cavity environment (artificial aging), thermal cycles were applied to all samples. These thermal cycles could cause changes in the micro spaces between the tooth and the veneer due to the presence of contraction and expansion stresses caused by the different coefficients of thermal expansion between the tooth structure and restorative material.(22) An automatic thermocycling equipment was used to do the thermocycling. Two external water reservoirs connected to the cold and hot internal reservoirs of a modified water coolant were part of the thermocycling system. The digital thermostats on the heater and compressor help to regulate the temperature between 5° and 55° C. The device had a third water tank for storing samples. (6).

A universal testing instrument (LARYEE universal testing machine, China) was used to conduct the fracture strength test. The crosshead speed for the load application was 0.5 mm/min. (3) with a specialized plunger (a steel rod with a flat end and 3.6 mm diameter) attached to the machine's upper moveable compartment (28) and positioned at the occlusal portion of the laminate veneer (23). To the tooth's long axis, the load was applied at a 45-degree angle (8). Using a mounting jig that was expressly created and made in the area, this orientation stayed constant. Computer software automatically recorded the maximum force required to cause fracture for each sample in Newtons (N).

RESULTS

1. Fracture strength test

There were recorded 45 fracture strength measures across all groups. For each group, the computed minimum and maximum values for the averages and standard deviations of fracture strength are shown in (Table 1-1). The findings of this investigation showed that Group C (189.53 N) had the highest mean fracture strength, followed by Group B (1 8 2 N), and Group A had the lowest mean fracture strength (162.67 N).

Further analyses of the mean difference in failure between every two groups were conducted using the least significant test. The fracture strength of Group A was statistically significantly different from Groups B and C (p 0.05) according to the LSD test results, although there was no difference between Group B and Group C. (table 1-2)

2.Color stability test

A total of 45 measurements of color stability for all groups were recorded. For each group, the estimated means and standard deviations of color change with lowest and maximum values are shown in (Table 1-3). According to the study's findings, group A had the largest mean color change (10.10), followed by group B (9.20), and group C(5.73). had the lowest mean color change value (0.02).

According to the results of the LSD test, Group C's color stability differed significantly (p 0.05) from Groups A and B while Groups A and B exhibited no significant variation. (Table 1-4).

DISCUSSION

Only human maxillary premolars were used in this study in order to reduce size variation, and teeth that experienced size changes were not included. In order to apply a copyplast template to all of the experimental teeth, a primary imprint and primary model were made, and they were afterwards removed. After surgically removing the extra material, a plastic coping was then made for each tooth's labial and occlusal surfaces. The veneer pattern, which was painted to act as a stopper during the insertion of the composite, was cut to within 1mm of its outline. To allow the extrusion of extra composite materials in groups A and C as well as the injection of flowable composite in group B, prepare an occlusal hole in the copyplast template's cusp tip position. (40)

To achieve precise tooth reduction, several number of approaches have been planned, such as Silicone matrices and depth-limiting burs. (13) All teeth had uniform buccal reduction utilizing cutter depth burs (Ceramic Veneer Set, Komet, Germany). Equal preparations of approximately 0.4 mm and 0.5 mm in depth were done in the cervical region and the occlusal two-thirds, respectively, to make sure that the preparation was only performed on enamel. (21) The cuspal reduction was occasionally used in the preparation. Comparing laminate veneers to teeth without cuspal reduction, it has been found that these two dimensions—1.5 mm occluso-cervical and 1.5 mm from the tip of the cusp palatally—display improved mechanical performance (lower stress concentration) (8).

In this study, the fracture resistance test was used because it is one of the main reasons veneers fail. The mean fracture load for Group C (restored with nanohybrid composite) was the greatest. This was associated with the increased mechanical qualities since filler weight and volume percentages were high (76% and 72%, respectively) (11) , Additionally, the mixture of nano- and microhybrid particles may be another factor in group C's increased fracture resistance. Large, agglomerated nanoclusters supporting tiny, tightly packed nanoparticles in this form of the composite increased its compressive strength, fracture resistance, wear resistance, and surface hardness. (45) Group B (which was restored with flowable composite) had the second-highest mean fracture strength. This form of composite has the most adaptation to the tooth structure and poses the least risk of pulling back, hence reducing voids at the edges. (7) In addition, compared to group A, which was restored with nano filled composite, the presence of 200-nm strontium glass fillers that were distributed uniformly may be associated with an increase in flexural strength and wear resistance. The composite's enhanced fluidity assures quick insertion with less stress, forming continuity between tooth surfaces, adhesive, and restorative material, allowing the resin to penetrate enamel even with minute defects, and forming a single body between the restoration and tooth structure(44). Group A, which had its fracture resistance reduced to the lowest level, was repaired using a nano-filled composite; this could be related to the composition and microstructure of the materials. Additionally, the composite included poorly performing mono-dispersed nanoparticles that are exclusively found in nanometric particles. There may not have been a statistically significant difference between groups B and C in terms of fracture resistance.

Test for color stability: A key aesthetic factor for tooth-colored restorations is color stability. (4) Numerous research has given a lot of attention to veneers' susceptibility to discoloration (39). It has become standard practice to assess such discoloration using colorimeters and spectrophotometers, such as Advance simple shade (58). Tea was chosen for the study's immersion solutions because it was thought to be a popular beverage. Comparing the certified materials' stain-resistance after 30 cycles of tea soaking was the research's secondary purpose. The immersion cycles were made to last 10 minutes twice day for 30 days in an effort to mimic the momentary contact of laminate veneers with tea before being washed away by saliva. Between immersion cycles, the samples were preserved in fake saliva to mimic the neutralizing effect of saliva. (49) The Group C restorations with direct nanohybrid composite veneers displayed the best color stability. This might be because the ratio of filler to resin matrix changed from 55.6% to 44.4% in group A to 62% to 38% in group C. As a result, Group C, which is in charge of fluid absorption leading to hydrolysis of the interface between resin and filler, had a lower resin percentage. The latter procedure may cause the fillers, which significantly contributed to the color shift, to separate. (31) Another factor could be the different types of resin. A hydrophobic monomer, UDMA, was thought to be more stain-resistant, whereas TGDMA exhibits some water absorption, allowing the entrance of a hydrophilic colorant into the resin matrix and resulting in increased discoloration (50). The poorest stain-resistant monomer according to BIS-GMA verification (36). This was consistent with the study's findings, which revealed that group A, which contains BIS-GMA, displayed the least amount of color stability among the C and B groups. As both groups C and B contain the same type of resin, being BIS-GMA free, this hypothesis might also help to explain the fact that there was a difference in color stability between the two groups. Because group C contains more resin (50%) than group B (38%), the increase in color stability there may be a result of this. (2). This is consistent with Bagher's finding that raising the TEGDMA fraction from 0% to 1% enhanced the water absorption of BIS-GMA-based based resin by 3-6%. (9) In Group C, which had the lowest color stability value, we, therefore, anticipate a rise in the amount of BIS-GMA.

Conclusions

The following results were reached within the constraints of this in vitro study: 1. All of the veneer types used in this study are suitable as a maxillary premolar treatment for patients with normal biting force. The use of laminate veneer in patient with parafunction should be carefully evaluated. 2. Direct veneer with nanohybrid composite demonstrated higher mean fracture resistance with a statistically significant difference compared to direct nanofiller composite veneers and a non-significant difference compared to direct veneer with flowable composite. 3. In terms of fracture strength, flowable composite and direct veneer with nanohybrid are the best veneering techniques 4. Direct veneer with flowable composite showed significant difference in fracture resistance in comparison to direct nanofill composite veneers. 5. Direct veneer with nanohybrid composite demonstrated a greater mean color stability with a difference that is statistically different from nanofill composite and flowable composite 6. Direct veneer with nanohybrid is the veneering method that offers the best color stability.

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Table (1-1): Descriptive Statistics: Mean values, standard deviation, minimum and maximum values of fracture strength for each group in Newton (N)

Groups	NO.	Minimum	Maximum	Mean	Std. Deviation
Group A (Nanofill composite veneer)	15	132	188	162.67	17.58
Group B (flowable composite veneer)	15	146	213	182.00	19.18
Group C (Nanohybrid composite veneer)	15	156	217	189.53	19.48
	45			178.07	21.61

Table (1-2): LSD Multiple Comparisons (least significant test)

(I)Group	(J) Group	Mean Difference (I-J)	Error Std.	Sig.
GroupA	GroupB	-19.3333-*	6.8520	0.007
	GroupC	-26.8667-*	6.8520	>0.001
GroupB	GroupA	19.3333*	6.8520	0.007
	GroupC	-7.5333-	6.8520	0.278
GroupC	GroupA	26.8667*	6.8520	<0.001
	GroupB	7.5333	6.8520	0.278

*The mean difference is significant at the 0.05 level.

Table (1-3): Standard deviation, minimum and maximum color change values, and mean values are all included in descriptive statistics.

Groups	N	Min.	Max.	Mean	Std. Deviation
Group A	15	6.93	14.41	10.10	2.93
Group B	15	6.11	13.48	9.20	2.24
Group C	15	4.08	8.01	5.73	1.20
Total	45	4.08	14.41	8.34	2.90

Table (3-7) Multiple Comparisons

(I) Group	(J)Group	Mean Difference (I-J)	Std. Error	Sig.
Group A	Group B	0.906	0.818	0.274
	Group C	4.374*	0.818	<0.001
Group B	Group A	-0.906	0.818	0.274
	Group C	3.467*	0.818	<0.001
Group C	Group A	-4.374-*	0.818	<0.001
	Group B	-3.467-*	0.818	<0.001

*. The mean difference is significant at the 0.05 level.

Fig.1

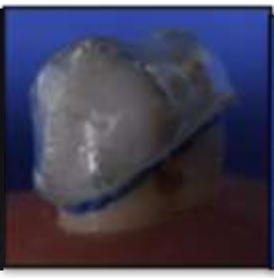

Fig. 2

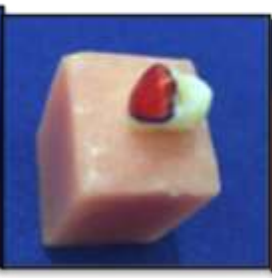

Fig.3

Fig. 4

Fig. 5

Fig. 6

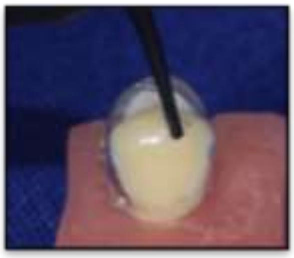

Fig. 7

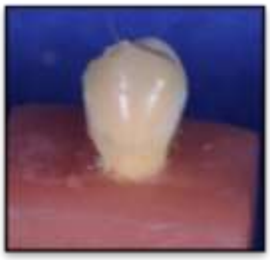

Fig. 8:

Fig.9

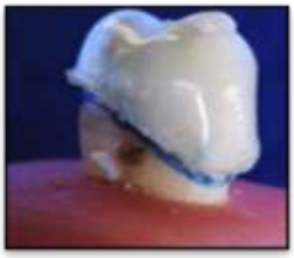

Fig. 10