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Comparative Evaluation Of Fracture Strength, Surface Hardness and Color Stability Between Pre-Formed And Customizable Direct Veneers: An *In Vitro* Study

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ABSTRACT
Dental veneers are steadily increasing in popularity among today's dental practitioners for rehabilitation of unaesthetic anterior teeth. The art of veneering has progressed over many years to the current generation of concepts and materials, which can be divided into directly fabricated composite resin veneers and indirectly fabricated veneers e.g., preformed laminates or laboratory fabricated acrylic resin, micro filled resin / indirect composite or porcelain veneers. The aim of the present study was to compare and evaluate the fracture strength, surface hardness and color stability between pre-formed and customizable direct veneers. The materials evaluated as study groups were composed of two groups namely, preformed veneers and discs (Edelweiss, Austria) (N=30) and Direct composite veneers and discs (Tetric N Ceram, Ivoclar Vivadent) (N=30). Both the groups were subdivided into two sub groups, each subgroup consisted of 15 veneers and 15 discs. 30 extracted human maxillary central incisors were selected and intra enamel veneer preparation was done and divided into two groups of (N=15) as stated above. 15 preformed discs (Edelweiss, Austria) were used and 15 direct composite discs (Tetric N Ceram) were prepared using a Teflon mould (8mm × 2mm), finished and polished. The fracture strength was performed by Universal Testing Machine at a cross head speed of 1 mm/min on the preformed veneers. Surface hardness was measured on the disc samples by a digital micro hardness tester. The finished samples were stored dry at room temperature 7 days prior to testing. The Vickers Hardness Test was used to measure the hardness. Color stability was measured for the disc samples at baseline (standard) and final (after immersion for 30 days) by a spectrophotometer. Tea and coffee were used as the immersing solutions. Color values (L, a*, b*) were measured over a white background, using CIE L*a*b* system. The data were statistically analyzed with independent's' test. The mean score value of fracture strength, surface hardness and color stability were seen to be more for pre-formed veneers as compared to the direct composite veneers. The difference between them was deemed to be very highly statistically significant (p<0.001) (Independent's' test). The preformed veneers seem to have better mechanical properties as compared to direct composite veneers.*
KEY WORDS: *Dental Veneers, Direct Composite Veneers, Preformed Veneers, Fracture strength, Surface hardness, Color stability.*

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INTRODUCTION

Veneers, one of the most revolutionary techniques developed over the past 25 years and at present, are one of the most opted conservative restorations for unaesthetic anterior teeth. One of patient's greatest desires when seeking dental treatment is the aesthetic transformation of their smiles to include healthy and harmonious dentition. Because of this, conservative treatments that are able to modify the shape, size and color of the teeth and that provide the result that the patient expects should always be the first therapeutic option. Such restorations often satisfy many of the same treatment objectives as conventional crown techniques, but with fewer clinical risks and complications.

Dental veneers have become an appealing treatment in dentistry spurred by the development of different materials and techniques, associated with the aesthetic patterns imposed by society. In general, patients who presented with clinical situations such as increased interdental spaces, fractures, deficient restorations or color changes in esthetic region are indicated for the treatment with veneers. The success of the veneers is associated with the dentist's knowledge, the technique used, the restorative material (dental ceramics and composite resin) and the patient's cooperation [1]. The art of veneering has progressed over thirty years to the current generation of concepts and materials, which can be divided into directly fabricated composite resin veneers and indirectly fabricated veneers e.g. preformed laminates or laboratory fabricated acrylic resin, microfilled resin / indirect composite or porcelain veneers [2]. The ideal requirements of a laminate veneer should provide excellent tooth contour with minimal thickness (not in excess of 0.5 mm), the surface and margins of the veneer should be smooth and be able to retain a high luster, shouldbe able to mask all forms of discoloration well without necessitating an excessive increase in bulk or contour, should be biocompatible to the gingival tissues, should be able to resist wear from the normal abrasive, erosive, and attractive processes present in the oral environment, should be highly resistant to extrinsic stains,should require little finishing at the chair side and it must also be cost effective [3].

Direct laminates are applied on prepared tooth surfaces with a composite resin material in the dental clinic. Minimal tooth preparation, low cost for patients compared with indirect techniques and other prosthetic approaches, reversibility of treatment and no need for an additional adhesive cementing system are some advantages of this technique. Intraoral polishing of direct laminate veneers is easy and any cracks or fractures on the restoration may be repaired intraorally and marginal adaptation is better than that of indirect laminate veneer restorations. However, the main disadvantages of direct laminate veneers are low resistance to wear, discoloration and fractures. Whereas, indirect laminate veneers are made outside the mouth using a strong and durable porcelain material or composites. Indirect laminate veneers have certain advantages compared to direct laminate veneer restorations like high resistance against attrition and fractures and discolorations. However, long chair time, higher cost and use of an adhesive cementing system are the main disadvantages of indirect laminate veneer restorations [4]. Furthermore, the greater the tooth reduction, the more likely it becomes that the enamel is removed, which is likely to jeopardize the retention of the planned aesthetic restoration [5].

Prefabricated composite resin veneers (PCRVs) are pre-shaped, pre-polished composite laminates available in different shapes and sizes for direct bonding to the tooth structure with a complementary shade-matched composite resin [6]. They are manufactured under ideal polymerization conditions with controlled light, pressure and temperature. This type ofveneering technique has many advantages such as it is minimally invasive, preserves naturaltooth structure, chair-side technique,requirement of single appointment, minimal time required to finish the treatment. The challenges include high technique sensitivity anddependent on the skill of the clinician [7].

The Direct Veneer System from Edelweiss was recently launched and is based on high pressure molding and heat curing processes, followed by laser surface vitrification [8]. The technique of lasersintering the enamel shells composed of nano- hybrid composite results in highly aesthetic surface enhancement. These prefabricated composite veneers are thinner shells of about lessthan 1 mm in thickness and hence tooth reduction on the labial surface would be veryminimal (0.3-0.5mm). Besides easy placement, which can be performed in a single appointment, this can be considered as a huge bio-aesthetic breakthrough in terms of dentist and patient alike. However, currently available literature lacks sufficient comparative data between preformed and customizable composite direct veneers. Hence, the present in-vitro study was done to evaluate the fracture strength, surface hardness and color stability between preformed and customizable direct veneers.

MATERIAL AND METHODS

A total of 30 extracted maxillary central incisors free from caries, free from any morphological defects and free from any previous restorations were collected. The selected teeth were mounted on an acrylic base. The Direct Veneer System (Edelweiss, Austria) were selected as preformed veneers (n=15). The preformed discs were also obtained from the same (8mm × 2mm) (n=15).

Fifteen Direct Composite Veneers were prepared on the selected extracted human maxillary central incisors (Tetric N Ceram, Ivoclar Vivadent) (n=15). Fifteen-disc (n=15) specimens were prepared from composite resin (Tetric N Ceram, Ivoclar Vivadent) of A2 shade that marketed for esthetic restoration. Composite resins were injected into Teflon moulds (8mm × 2mm) and placed over mylar strip on a glass plate. Finger pressure was applied to the glass plate to expel excess materials and create a smooth surface. The composite resins were then polymerised using LED light-curing unit for 40 s to allow thoroughpolymerization. The discs were removed from the moulds, stored in deionized water for 24h to complete polymerization, and then finished and polished.

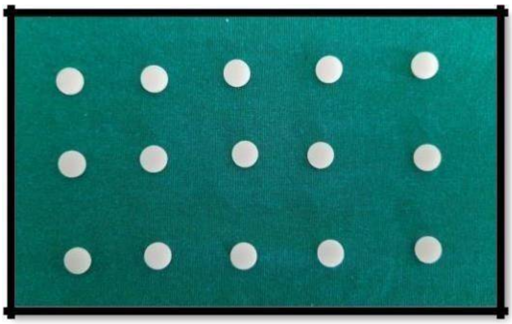


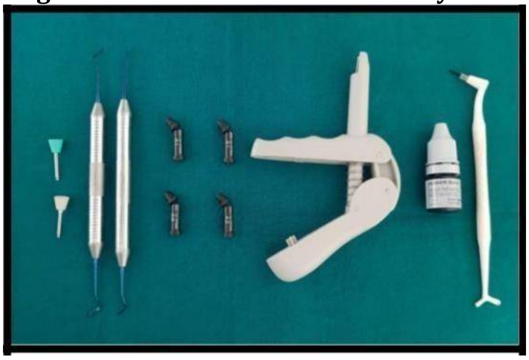
Figure 1. Edelweiss Direct Veneer **Figure 2. Edelweiss Preformed Disc**

In order to evaluate the color stability of different veneering materials, two different beverages were used in this study: {1} Coffee and {2} Tea. A 3.6g of coffee powder was dissolved in 300ml of boiling distilled water. After 10min of stirring the solution was filtered through a filtered paper. Tea solution wasprepared by immersing prefabricated tea bags into 300 ml of boiling water. Tooth preparation for veneer was done on all the extracted teeth using depth cutting and long tapered round end tooth preparation burs (Shofu, Japan). Following guidelines of veneer preparation, extracted human maxillary central incisors were used to optimally represent the clinical situation and teeth were prepared using diamond depth cutting bur. For tooth preparation of veneers 0.3-0.5 mm depth grooves were prepared with the help of depth orientation bur and further tooth preparation was done with tapered round end bur and chamfer finish line was made. To ensure that the whole preparation remained within the enamel, tooth preparation started with horizontal orientation grooves (0.3mm), cut with a depth cutting diamond bur. The grooves were then levelled with long tapered round end bur to achieve a preparation depth of approximately 0.5 mm.

Figure 3: Teflon Mould **Fig 4: Finished Veneer preparation**

Study groups:
Two groups were formulated:
Group I: The group consisted of 30 samples for preformed Edelweiss Veneers and Preformed disc specimens.
Subgroup I: This group consisted of 15 preformed Edelweiss Veneers.
Subgroup II: This group consisted of 15 preformed Edelweiss disc specimens.
Group II: The group consisted of 30 samples for direct customizable composite veneers and prepared composite disc specimens.
Subgroup I: This group consisted of 15 direct composite veneers
Subgroup II: This group consisted of 15 prepared composite disc specimens.
The bonding agent (Veneer Bond, Edelweiss) was applied on preformed veneers and light cured for 15 seconds. The veneers were then luted on their respective prepared teeth after acid etching enamel using 37% phosphoric acid for 15 to 20 seconds with luting cement (Edelweiss Composite, Edelweiss) and allowed to set. Excess cement was removed with explorer tip.

Figure 5: Edelweiss Direct VeneerSystem



From Right to left:
a) Applicator tip
b) Veneer Bond, Edelweiss
c) Compule Gun, Oro
d) Nanohybrid Composite Compules
e) Composite Instruments, API
f) Polishing cups

Whereas, the remaining prepared teeth were etched using 37% phosphoric acid (Eco-etch, Ivoclar Vivadent) for 15 to 20 seconds. Thorough irrigation was done with water spray to remove the etchant. After drying, bonding agent was applied and light cure for 15 seconds. Then, direct composite veneering was prepared on teeth with light cure composite resin (Tetric N Ceram, Ivoclar Vivadent). The teeth were then finished and polished.

The specimens were stored in deionized water at room temperature for one month prior to fracture, which was performed in Universal testing machine. This machine had two column load frames for testing compression and tension. It was a highly sensitive and accurate load weighing machine. The specimens were placed on the lower platform which was stationary and the crosshead was moved up and down so as to test the specimens. The load was applied at a crosshead speed of 1 mm/min from the incisal direction to the veneer-tooth interface until fracture of the veneer or the tooth occurred. Each sample was mounted in testing machine at 45^o to the long axis. The maximum load to produce fracture of each specimen was recorded in Newton (N), entered into a Microsoft Excel spreadsheet program, and imported into a statistical program.

The finished samples were stored dry at room temperature for 7 days prior to testing. After the storage periods, Vickers surface hardness testwas performed using a digital microhardness tester. In the Vickers surface hardness test, a diamond in the shape of pyramid is used to make the indentation with a force load. Three indentations per specimen were made with a loadof 0.5 N and a loading time of 40 s, and the diagonals were measured with a 40X magnifyinglens.

The specimens were tested for color stability using a digital spectrophotometer according to CIELAB (Commission International de l'Eclairage, L*, a*, b*). *). The CIE L* corresponds to degree of lightness and darkness, whereas a* and b* coordinates corresponds to the amount of red or green (+a* = red, -a* = green) and yellow or blue (+b* = yellow, -b* = blue) respectively. Initial color measurements were taken for the discs which represent the baseline measurement and then they were immersed in solution (coffee and tea) for 30 days. The color measurements were done before immersion (baseline) and after 30 days immersion. Each specimen was dried using blotting paper before color measurement. The color difference (ΔE) between the baseline and after immersion measurements was calculated using the following equation:

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

STATISTICAL ANALYSIS

The statistical software namely SPSS 19.0 was used to analysis of the data and Microsoft excel have been used to generate graphs, tables, etc.

Inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ±SD and results on categorical measurements are presented in Numbers (%). Significance is assessed at 5% level of significance. Independent 't' test has been used to find the significance of study parameters on ordinal scale between two groups.

RESULT AND DISCUSSION

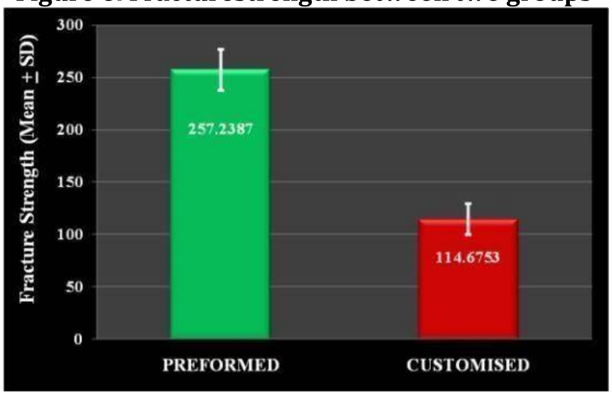
Fracture strength of the samples was measured with the help of universal testing machine. The results obtained were subjected to statisticalanalysis using Independent's' test and represented as following: In Group I, Subgroup I preformed veneers(mean value was 257.2387±19.5143) and in Group II, Subgroup I customizable direct composite veneers (mean value was 114.6753±14.5557). Preformed veneers were found to be having more compressive strength compared to direct composite veneers and difference in compressive strength was found tobe statistically very highly significant (p<0.001).

Table 1: Mean Fracture Strength (N) Among The Two Groups

Group	**N**	Fracture Strength		**Independent 't' test**	**p - value**
		Mean	**SD**		
Preformed	15	257.2	19.51	22.680	< 0.001*
Veneers		38	43		
Customizable		114.6	14.55		
veneers		75	57		
	15				

SD – Standard Deviation, * - Very HighlySignificant

Figure 6. Fracturestrength between two groups



Surface Hardness of the samples was measured with the help of digital microhardness tester. The results obtained were subjected to statisticalanalysis using Independent's' test and represented as following:

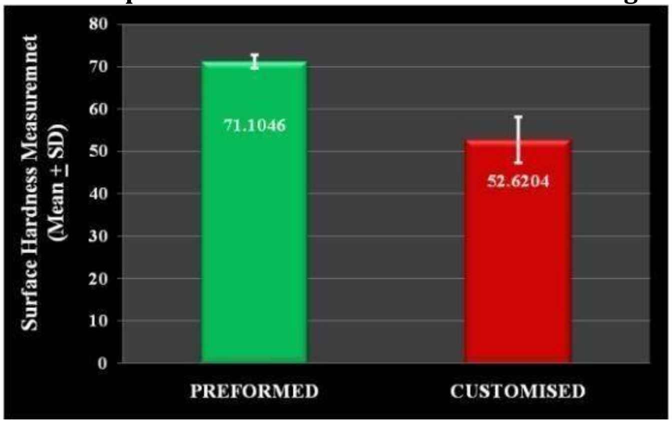
Table 2: Mean Hardness Value (Hv) AmongTwo Groups

Group	**N**	Surface Hardness Measurement		**Independent 't' test**	**p – value**
		Mean	**SD**		
Preformed Discs	15	71.1046	1.5788	12.724	<0.001*
Customized Discs	15	52.6204	5.4003		

SD –Standard Deviation, * - Very Highly Significant

In Group I, Subgroup II preformed disc (mean value is 71.1046±1.5788) and in Group II, Subgroup II customizable direct compositeveneers (mean value is 52.6204±5.4003). Preformed veneers were found to be having better hardness compared to direct composite veneers and difference in hardness values was found to be statistically very highly significant (p < 0.001).

Figure 7. Comparison of surface hardnessbetween two groups



The color values were recorded using a digital spectrophotometer. The samples were recorded for baseline measurements before immersion in solution and then recorded after immersion for storage period. The L*, a* and b* values were then subjected for statistical analysis. The mean and standard deviation values of color change ΔE of the samples after immersionin solution for each of the group used in the study are summarized in Table 3 and Graph 3.

Table 3. Color Changes for both groups after 30 days immersion)

Group	N	Color Stability (ΔE)		**Independent 't' test**	**p – Value**
		Mean	**SD**		
Preformed	15	6.2497	1.0902	- 6.843	<0.001*
Customized	15	11.3835	2.6932		

SD – Standard Deviation, * - Very HighlySignificant

The difference between color changes (ΔE) of both groups after storage period was statistically very highly significant (P<0.001). The preformed discs were found to be most color stable (ΔE= 6.2497±1.0902), whereas the direct composite discs were least stable (ΔE = 11.3835±2.6932).

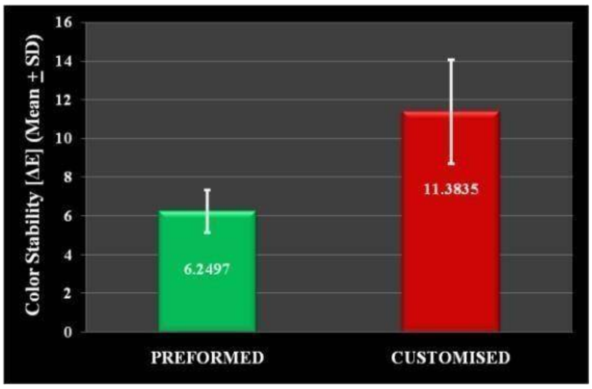


Figure 8. Comparison Of (Δe) ColorChanges Of Both Groups

The specific objective of the present in vitro study was to compare and evaluate the fracture strength, surface hardness and color stability between preformed and customizable direct veneers. Dental veneers are tooth-colored shells attached to the front surfaces of natural teeth and are an easy way to address a variety of physical and aesthetic problems. Historically, Dr. Charles L Pincus introduced the concept of veneering anterior teeth with laminates when approached by Hollywood directors in 1928. However, it was Buonocore's research about acid etching technique in 1955s, which provided a simple method for increasing adhesion to enamel surface[5]. Due to increased aesthetic demand and the possibility of joining laminates to the tooth structure (particularly enamel), a new concept was introduced: minimally invasive restorativedentistry, which caused little damage to dental structures. With that in mind, laminate veneer, also known as contact lenses emerged. Laminateveneers should be used as a conservative solutionto an aesthetic problem. The correct indication for their use is the main factor in the clinical success of the application of materials. Such type of restorations has two different types, namely direct and indirect laminate veneers, which have their own advantages and disadvantages respectively.

With increasing demand for aesthetic treatments, there have been day to day developments of dental materials that meet both aesthetic and functional requirements of patients. In modern days, new prefabricated composite resin and ceramic veneers (PCRVs) have become available. The concept of prefabricated resin-based veneers is not new. In the early 1980s, prefabricated acrylic veneers were introduced as Mastique Laminate Veneer System (Caulk, Milford, DE, USA) but with somewhat limited success due to former technological limitations and hence this riveting treatment option was replaced with the increase in ceramic veneering technique [7-11]. Recently this concept has been reinvented with the help of newer technology via. Surface laservitrification. Edelweiss dentistry presents a newer concept of direct esthetic restoration using prefabricated veneers. It is processed on high pressure moulding and heat curing processes, followed by laser surface vitrification which enables the veneers toexhibit a hard and glossy surface. However, there has been very little information on the mechanical properties of such PCRVs and Stheir processing conditions. Hence, the present study was undertaken.

One of the factors that greatly influence the longevity of both direct composite and indirect veneer restorations is the strength and long- term reliability of the adhesion to the tooth structure. During the process of mastication, teeth are constantly subjected to mechanicaland thermal cycles and restorative materialsdevelop fatigue and fail/fracture eventually. Compressive stress testing is used forevaluation of the mechanical properties of restorative materials. Since most of the masticatory forces fall into the category of compressive forces, assessment of the durabilityof restorative materials in such conditions is of great importance. Therefore, it is especially important to restore teeth with materials than can handle such pressures[12]. In the present study, Table 1 and Graph 1 represented the mean and standard deviations in fracture strength between preformed and direct composite veneering. It was observed that the mean fracture strength for Preformed Veneers (257.2387±19.5143 N) was greater than Direct Composite Veneer (114.6753±14.5557 N). Hence it can be assumed that the preformedveneers had more resistance to fracture than that of direct composite veneers. The difference in the compressive strength mean score was found to be statistically very highly significant (p value <0.001). This is in agreement with a in vivo study done where they evaluated the clinical performance of prefabricated veneer restorations. It was noted that prefabricated composite veneers were easier to modify and provided better esthetics if luted with the same material as used for its fabrication. They concluded that with preformed veneers, using the enamel reduction and heat adaptation techniques, provided an aesthetic, conservative and functional restoration [13]. The present study on Edelweiss veneers is also based on the same facet; wherein the Edelweiss veneers are subjected to heat treatment for improved mechanical properties and was luted with highly filled edelweiss nanohybrid composite resin; to create a stable monoblock restoration. In another study where the effect of experimental heat treatment on mechanical properties of resin composites was evaluated. It was concluded that resin composites when subjected to heat treatment presented a higher degree of conversion and improved mechanical properties in comparison to solely light cure materials [14]. In context to the present study, the preformed Edelweiss veneers used are fabricated from nanohybrid composite and it further undergoes laser sintering to attain a dynamic composite core, which aided in betterstrength.

Hardness is defined as the resistance to surface indentation and can be used as an indirect method for measuring the degree of polymerization. The material hardness is extremely influenced by their composition. Materials with higher inorganic filler size tend to exhibit higher mechanical properties. The degree of conversion can be correlated with the hardness of the composite and both parameters are extremely affected by the light curing unit used, time/irradiance and material composition. In present study, Table 2 and Graph 2 represented a higher surface hardness mean for the preformed disc on comparison with direct composite group. The Vickers hardness number was calculated for the present study. On statistical analysis, very highly significant differences were observed between two groups (p <0.001). The mean hardness value for preformed disc was found to be 71.10462±1.5788, whereas the direct composite discs observed a mean hardness value of 52.6204±5.4003. Corroborating with the present results, preformed discs represented improved hardness values owing to the laser treatment and polymerization they undergo in a laboratory condition and hence had a high degree of conversion. This comes inagreement with a study where the microhardness of two different PCRVs (Componeer & Edelweiss) was evaluated. Itwas stated that both of the PCRVs presented similar hardness value owing to their inorganiccontent (filler size) and manufacturing conditions [15].

Another feature that should be investigated and experimented over time is the color stability of the veneering materials. Discoloration in resin composites can be extrinsic discoloration, or intrinsic (subsurface) discoloration. The staining ability of the composite is related to resin matrix, percentage of filler particles and adsorption and absorption of stains. It has been noted that a composite with large filler particles are more prone to water the aging discoloration than a composite with small filler particles, which is in line with the hydrolytic degradation matrix filler interfaces[16]. Colorperception is often regarded as a psychological issue and is affected by the observer's skill and often reported differently on differentoccasions. To overcome such errors color evaluating devices were employed and data were recorded in CIE L*a*b* system [17]. In the present study the color change was compared using three values of ΔE, namely, the overall color change after a period of submission. In our study, (ΔE ≥3.3) was taken as perceptiblecolor change as it has been reported that the human eye could not detect ΔE values less than and ΔE ≤3.3 was the critical value for the visual perception of the restorative materials. Table 3 and Graph 3 indicated that the amount of ΔE in both the groups was >3.3, which showed that both the groups had increased ΔE values. However, the preformed discs were found to be most color stable and the direct composite discs were least stable.

One study evaluated the effect of beverages on the color stability of micro filled and nanohybrid filled resin. Color stability of nanohybrid filled resin was found better than the micro filled composite. As stated earlier that the preformed veneers used in this study are fabricated from nanohybrid composite and subjected to a specific surface treatment with a laser. It has already been cited above that the specific laser treatment produces a smooth surface vitrification with increased hardness, wear resistance and color stability. Several factors can affect the color stability of the composites. Low degree of conversion can generate residual non-reactive components at the crosslink network. These components can be leached by water, which would increase the solubility and consequently decrease the color stability. Since the polymerization of the PCRV's are performed under ideal laboratory conditions, it is theorized that few non-reactivecomponents will be formed and the material should present higher color stability. With direct composite veneers, the disadvantages include polymerization shrinkage and inadequate contour. However,the composition of indirect or preformedcomposite resin systems is similar to that of direct systems, differing in terms of the use of different methods of additional polymerization, which allows a higher radical conversion. These additional polymerization procedures can involve photo-activation, heat, pressure, and thermal tempering, as previously described. Therefore, it is expected that preformed composite veneers show better properties than direct composites because of the possibility of better activation of polymerization reactions.

Hence, the null hypothesis of the present investigation has been rejected. In the present study, very highly significant differences were reported between the preformed and direct composite veneers. Thus, it is very evident from this study that preformed veneers had better mechanical properties in terms of strength, hardness and color stability when compared to direct composite veneering. The higher values of fracture strength and surface hardness and better color stability can be well attributed to the fact that the advanced fabrication technology with heat/pressurecomposite curing and laser sintering used in the preformed veneers.

CONCLUSION

Within the limitations of the present study, the results indicated that the preformed veneers had superior mechanical properties than that ofdirect composite veneers owing to the lasersintering concept. Hence, it was concluded that preformed veneers showed better fracture strength compared to direct composite veneers. Direct composite veneers showed lower surface hardness compared to preformed veneers. Preformed veneers demonstrated lesscolor change compared to direct composite veneers.

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