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Evaluation of the Flexural Strength of Submicron Hybrid Composite using Different Fabrication Methods: An *in vitro* Study

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ABSTRACT

Aim: The aim of this study is to perform three-point bend test on submicron hybrid composite fabricated with direct and indirect veneer technique.

Materials and methods: A total of 20 maxillary anterior teeth were selected, and labial reduction of 0.5 to 0.75 mm with a chamfered finish line for veneer preparation was done. Teeth were divided into two groups depending on fabrication technique being used: group I—veneers fabricated with light and group II—veneers fabricated with light and heat (PHOTOPOL). Specimens were tested under universal testing machine (UTM) where load was applied at a crosshead speed of 1 mm/min with a pointer of 1 mm diameter. Data were statistically analyzed.

Results: The results showed highly significant difference between the two groups with the mean value of group I (246.7 ± 2.285 N) and group II (531.1 ± 4.411 N).

Conclusion: The curing mechanism involving light and heat increases the fracture resistance of the veneers.

Clinical significance: Within the limitations of this study, the results led to the conclusion that the association of common composites with a simple postcure heat treatment may be an alternative for current indirect composite systems, although more studies are needed to assess other properties of the composites for this application.

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INTRODUCTION

Esthetic and biomimetic adhesive dentistry has been made possible by the numerous advances in dentin-enamel bonding and the development of composite resin materials with improved mechanical properties.[1,2] Direct composite veneers are usually considered as a more conservative approach to the porcelain, and with the emergence of micro- and nano-hybrid composite resins, the finishing and polishing of these restorations can withstand the porcelain veneers.

Nowadays, survival rates of direct composite resin exceed those of amalgam and present less risk of tooth/restoration fracture and cracking.

One of the drawbacks of direct composite resin restorations is polymerization shrinkage. The ultimate solution to this problem is the use of indirect restorations.[3]

Currently, indirect composite restorations can be fabricated with materials originally intended for direct use by the dentist or with specific indirect materials for laboratory use, i.e., only light and heat polymerized. Although indirect composite restorations have identical composition, still they have better mechanical properties and the reason behind this is higher levels of monomer conversion which can be often achieved by the use of various polymerization procedures that involve photo-activation, heat, or both.[4,5]

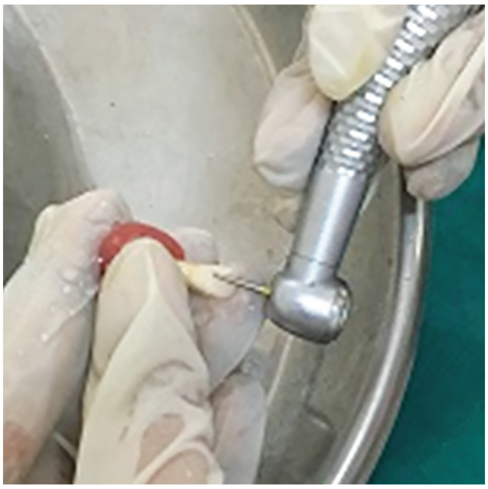

Fig. 1: Veneer preparation

Fig. 2: Veneer cured with light

da Silva et al[6] evaluated mechanical properties of light-curing composite polymerized with different laboratory photocuring units and that microhardness of the resin composite was affected by the composition and also by the type of laboratory photocuring unit used. The mechanical properties of the composites were upgraded by the use of light along with the heat curing.

The persistent advancement and evolution in restorative materials and techniques offer clinicians a whole plethora of esthetic materials with improved mechanical properties and at a different expenditure.

One of the methods to determine the strength of any material is by three-point bend test.[7,8] In this test, pressure is applied on the central part of the restorative material; the initial crack and fracture usually starts from the sites with any defect and flows in the material. This tells us about the flexural strength of the material.[8]

Veneers prepared with composite must have sufficient flexural strength. Thus, this *in vitro* study was planned to evaluate three-point bend strength of newer composite material cured with direct and indirect method.

MATERIALS AND METHODS

Freshly extracted 20 intact human maxillary anterior teeth were collected for the study and stored in distilled water before use. Teeth with caries, fracture and cracks, erosion and abrasion, and morphological abnormalities were excluded from the study. The materials used were composite (BRILLIANT Everglow—Coltene), light-curing unit (confident), Photopol unit, metal pipe acrylic resin, UTM, and metal base.

All the samples underwent a labial reduction of 0.5 to 0.75 mm with a chamfered finish line for veneer preparation as shown in Figure 1. The cervical preparation ended at cement-enamel junction, and smooth margins were created to prevent the stress concentration zone. After the completion of the preparation, impression was taken for all the 20 samples using polyvinyl siloxane (zetaplus) impression material. Cast was poured using type IV dental die stone.[9,10] Stone dies were carefully separated from the impression and teeth were randomly divided into two subgroups:

Fig. 3: Veneer cured in Photopol unit

1. *Group I*: Veneers fabricated with light (n = 10) (light-emitting diode light-curing unit) are shown in Figure 2.
2. *Group II*: Veneers fabricated with light and heat (n = 10) (Photopol unit) are shown in Figure 3.

In group I, composite veneers were cured using light only, while in group II veneers, they were cured with light and heat. Finishing of the composite veneers was done using the composite polishing kit (Shofu).

In both the groups, veneers were not bonded to teeth. To evaluate three-point bend test, veneers were embedded perpendicularly in polymethyl methacrylate, and load was applied with UTM (Tinius Olsen) to the middle of the test specimen at a crosshead speed of 0.1 mm/min using 0.1 mm diameter, as shown in Figure 4.[7,8]

Fig. 4: Application of the load cell to the veneer until fracture in a universal testing machine

The values obtained for each sample of both the groups were tabulated and put to statistical analysis.

RESULTS

The readings of the UTM at which veneers fractured were noted (Table 1), and data were analyzed by GraphPad Prism test. The lowest mean fracture load was obtained for group I veneers which were fabricated using light only (246.7 N), whereas the highest was obtained for group II that was indirectly cured with composite veneers (531.1 N). There was a highly significant difference between the mean flexural strength of group I (246.7 ± 2.285 N) and group II (531.1 ± 4.411 N).

DISCUSSION

Reestablishing a patient's missing natural dental esthetics is one of the major concerns in today's dentistry, in addition to function and phonation.[11] Color, shape, and structural and position abnormalities of anterior teeth might lead to important esthetic problems for patients.[12]

Table 1: Fracture strength of veneers obtained in Newtons

Sample	*Group I*	*Group II*	*p-value*
1	250	500	<0.0001 (significant)
2	238	550	
3	242	545	
4	246	530	
5	245	524	
6	252	535	
7	260	532	
8	249	525	
9	235	528	
10	250	542	
Mean value	246.7 N	531.1 N	

However, extensive preparations of teeth and damage to surrounding tissues, such as gingiva, are some of the drawbacks associated with crowns.[13] Therefore, in recent years, laminate veneer restorations, as a more esthetic and more conservative treatment option, have been used in dentistry.

Laminate veneers are used to correct the existing abnormalities, esthetic deficiencies, and discolorations.[11-13] Laminate veneer restorations have two different types: Direct and indirect laminate veneers.

Direct or indirect veneers are restorations that improve the esthetics of the tooth by changing color, position, and form in a minimally invasive approach compared with their full coverage crown counterparts.

In today's scenario of conservative preparations, the most preferred and deliberately used is composite resins. They can be described as inorganic particles packed within an organic matrix and joined together by a silane coupling agent.[14] Mechanical properties of resin composites are vastly influenced not only by their chemical composition but also by the degree of monomer conversion. A light-sensitive material contains camphorquinone, so when activated reacts with a reducing agent, and for adequate polymerization, it needs a suitable wavelength and sufficient light intensity. However, the properties can be improved by utilizing the secondary polymerization methods.

Cook and Johannson[5] reported that through the free radical polymerization of the methacrylate moieties, composite resins are converted from the viscous resin to a rigid solid.[15] Bausch et al[16] explained that in dental composite resin system two polymerization reactions take place:

1. Formation of long polymer chains
2. Formation of cross-links between chains.[15]

At low energy, the first reaction predominates the second one. In the beginning of the polymerization reaction during dental restorative application, peroxide molecules of the catalyst system are split up chemically. Lee and Orlowski[17] stated that with the rise in temperature heat can also begin the reaction.[17] Moreover, due to exothermic nature of the reaction polymerization reaction itself dissipates the heat; therefore, the reaction is temperature and mass dependent.[15]

The experiment conducted by Bausch et al[16] demonstrated that the effect of temperature on free radical polymerization is of considerable importance to structure of resulting polymer. Mechanical properties of composites were remarkably improved with the rise in curing temperature. In a clinical situation, a proper heated restoration will be less toxic due to the absence of residual monomer leaching.[18]

The hardness of the bottom surface is lower than the top surface, possibly due to shortage of free radicals available at the bottom surface. Both the diametral tensile strength and the compressive strength of almost all composites raised on secondary curing by heat which indicates a beneficial state for the clinical implication.

Miyazaki et al[8] studied the heat treatment of a direct composite resin influence on flexural strength, and found that light followed by heat curing increases the flexural strength of composites. Up to 6 hours, higher monomer conversion occurs after photoactivation and there is a reduction in the amount of residual monomers after 6 hours. After that period, the heat treatment did not lead to an increase in flexural strength.[19]

The main objective of the present study was to determine and evaluate the flexural strength of veneers prepared with newer submicron composite material cured with light alone and when cured with light and heat.

The results of our study are in concurrence with the study of Miyazaki et al,[8] which showed that light curing followed by heat increased the flexural strength of the veneer. With light curing alone, the values obtained for flexural strength were 246.7 N, while it almost doubled (531.1 N) following exposure to heat curing.

In contrast, Wendt[20] concluded that the use of heat as a secondary curing method does increase the diametral tensile strength, but compressive strength of composite resin was not increased or decreased on heat curing. The shrinkage of the composite resin after heat application can be attributed to resin matrix, filler volume, and particle size.

The increase in flexural strength following heat curing is significant not only for mechanical properties of the material but it also improves the biocompatibility of the material as there is a decrease in the potential leachable unreacted monomer.[19]

The use of light and heat units is still limited, and thus, more studies in this direction are recommended.

CONCLUSION

It can be concluded that veneers fabricated with light and heat had better flexural strength when compared with the veneers fabricated with only light. Due to increased mobility, the curing performance with postcure heating was enhanced consequently and during irradiation free radicals formed on secondary cure were highly reactive.

Clinical Significance

The flexural strength of the composite raised on postcuring by heat, and this may be a sign of a better cured state, which is clinically also beneficial.

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