

Fracture strength of laminate veneers using different restorative materials and techniques (A comparative in vitro study)

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ABSTRACT

Background: Esthetic correction represents one of the clinical conditions that required the use of laminate veneers in premolars region. **Aim of the study:** The purpose of this study was to evaluate the fracture strength of the laminate veneers in maxillary first premolars, fabricated from either composite (direct and indirect techniques) or ceramic CAD/CAM blocks.

Materials and Methods: Fifty sound human maxillary premolar teeth were used in this in vitro study. Teeth were divided randomly into one control group and four experimental groups of ten teeth each; Group A: Restored with direct composite veneer (Filtek Z250 XT), Group B: Restored with indirect composite veneers (Filtek Z250 XT), Group C: Restored with lithium disilicate ceramic CAD/CAM blocks (IPS e. max CAD) and Group D: Restored with resin nano ceramic CAD/CAM blocks (Lava Ultimate Restorative). Standard preparations were done using Ceramic Veneer Set (Komet). Indirect laminate veneers were cemented with the Relyx Veneer Cement (3M ESPE) and all specimens were stored in distilled water at 37°C for 2 weeks. The load was applied on the occlusal part of the veneer at 45° to long axis of the tooth using universal testing machine. Results were analyzed with one-way ANOVA and LSD tests. Specimens were examined by stereomicroscope at a magnification of 20x to evaluate the mode of failure.

Results: Control group showed higher mean of fracture strength with highly significant difference in comparison to the experimental groups ($P < 0.01$). (Group A) showed higher mean of fracture strength with statistically significant difference in comparison to (Group B and Group D). On the other hand the difference between (Group A and Group C) was statistically highly significant. Statistically non-significant difference was found among the three indirectly restored groups.

Conclusions: All veneers used in this study can be considered as acceptable treatment in the premolars region for patients with normal biting force. Direct composite veneer is the most favorable technique in term of fracture strength, while IPS e. max CAD laminate veneers were least likely to fracture and most likely to completely debond.

Keywords: Laminate veneers, direct composite, indirect composite, lithium disilicate ceramic, resin nano ceramic, fracture strength. (J Bagh Coll Dentistry 2014; 26(4):1-8).

الخلاصة

يمثل التصحيح التجميلي واحدة من الحالات السريرية التي تتطلب استخدام القشور التجميلية في المنطقة الضواك العلوية. الغرض من هذه الدراسة كان لتقييم قوة كسر القشور التجميلية في أسنان الضواك، مصنوعة من المواد المركبة أو من قوالب السيراميك باستخدام ثلاثة طرق مختلفة: المباشرة، الغير المباشرة و باستخدام تقنية ال CAD / CAM. تم اختيار خمسين سنا من الضواك العلوية لأشخاص بالغين، تم تقسيم الأسنان بشكل عشوائي في خمس مجاميع؛ مجموعة قياسية و أربع مجموعات تجريبية (عشرة أسنان لكل منهم)؛ المجموعة (أ): رمت باستخدام القشور التجميلية مصنوعة من المادة المركبة بصورة مباشرة على الأسنان (Filtek Z250 XT, 3M ESPE)، المجموعة (ب): رمت باستخدام القشور التجميلية مصنوعة بطريقة غير مباشرة على قالب الحجر باستخدام المادة المركبة (Filtek Z250 XT, 3M ESPE) المجموعة (ج): رمت باستخدام القشور التجميلية المصنوعة من قوالب سيراميك الليثيوم ثنائي السيليكات (IPS e. max CAD, Ivoclar Vivadent) و المجموعة (د): رمت باستخدام قشور تجميلية مصنوعة من قوالب راتنج نانو سيراميك (Lava Ultimate Restorative, 3M ESPE). في المجموعتين (ج و د)، تم صناعة القشور التجميلية باستخدام تقنية ال CAD / CAM (Ceramic Veneer Set). تم تثبيت تعويضات القشور التجميلية الغير مباشرة باستخدام السمنت المركب الراتنجي (Relyx Veneer Cement) المتصلب بالأشعة الضوئية و خزنها بالماء المقطر بدرجة حرارة 37° لمدة اسبوعين قبل اجراء فحص قوة الكسر باستخدام جهاز الاختبار (Universal testing machine). تم تحليل النتائج احصائيا باستخدام اختبار (ANOVA) واختبار اقل فرق معنوي (LSD test). وقد تم فحص العينات الفاشلة تحت المجهر لتحديد نمط الفشل. في الختام استنادا الى نتائج هذه الدراسة، يمكن استخدام القشور التجميلية للأسنان الضواك العلوية ولكن استخدامه للمريض مع خطأ في أداء الوظيفة الاطباقية ينبغي تقييمه بعناية. القشور التجميلية المصنوعة من المركب الراتنجي بالطريقة المباشرة هو الأسلوب الأكثر ملاءمة من حيث قوة الكسر في الضواك.

INTRODUCTION

Esthetic or cosmetic dentistry has become one of the main areas of dental practice emphasis and growth for several years. Recently, the main reason for applying restorative dental materials is not only to restore dental tissues lost because of caries or trauma, but also to correct the form and color of teeth for social acceptance ⁽¹⁾. As smile design not only means designing teeth, but also creating a smile that truly complements the patient's face and personality. Following this philosophy, recreating a smile need not be limited

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to the anterior teeth, but may extend to include the posterior teeth ⁽²⁾.

Crown preparation involves significant removal of tooth structure and may cause pulpal irritation and irreversible pulpitis. While laminate veneers are more conservative than crowns and maintain the biomechanics of the original tooth with a similar stress distribution and a success rate of approximately 93% over 15 years of clinical use ^(3,4).

According to literature the most frequent failure modes associated with laminate veneers are fracture and debonding. Fractures of laminate veneers represented 67% of the total failures of such restorations over a period of 15 years of clinical performance ^(3,4).

Little information is available in the literature on the survival rates of different laminate materials. There was no evidence as to whether indirect laminates are better than direct ones and whether it suitable to withstand biting force in premolars region.

MATERIALS AND METHODS

Fifty sound human maxillary first premolars extracted for orthodontic treatment with comparable dimensions were selected for this in-vitro study. The occluso-cervical and mesio-distal dimensions were measured. To determine that the enamel was free from cracks, all teeth were visually examined under blue light transillumination. Teeth were cleaned by scaling and stored in distilled water at room temperature^(5,6).

Teeth were then randomly divided into five groups of 10 specimens each:

- Control group: Intact teeth.
- Group A: Restored with direct Composite veneers\Filtek Z250 XT.
- Group B: Restored with indirect Composite veneers\Filtek Z250 XT.
- Group C: Restored with CAD/CAM veneers\IPS e.max CAD blocks.
- Group D: Restored with CAD/CAM veneers\Lava Ultimate Restorative blocks.

The teeth were mounted individually in specially designed, locally-manufactured rubber mold (30 mm height × 30 mm diameter) with cold cure acrylic (Vertex, Netherlands) with the long axis of the tooth parallel to center of the mold. Each tooth was suspended in the middle of the mold using a Ney Surveyor (Bego, Germany) to ensure vertical positioning of the tooth inside the mold. All specimens were embedded up to 2 mm apical to the CEJ to simulate the natural biologic width⁽⁷⁾ as seen in (Fig.1).

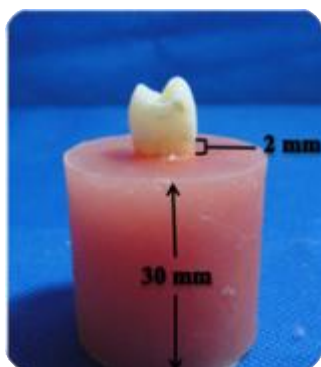


Figure 1: Tooth mounted in acrylic block 2 mm apical to CEJ.

Primary impression and primary model was prepared for all experimental teeth which was used to fabricate copyplast template for group A and group B, while for group C and group D, the primary model was used to take a biocopy for creating laminate veneers of the original size and shape of the teeth^(8,9).

A copyplast template was fabricated for each tooth in Group A and Group B using 0.5 mm thick vacuum pressed polyethylene plastic template in a vacuum forming machine. Then a sectional index was produced using a putty polyvinylsiloxane material (Zhermack, Italy) before the preparation to evaluate the consistency of tooth reduction.

Before starting, the outline of the preparation was painted with a waterproof color marker. Magnification loupes (2.5x) were used during the whole tooth preparation procedure which was done under constant water irrigation. Standardized preparations were done for all the teeth using ceramic veneer system preparation bur set (CVS for porcelain veneers, Komet, Germany). The facial reduction was 0.4 mm at the cervical third and 0.5 mm at the middle and occlusal thirds⁽¹⁰⁾. The preparation ended 1 mm occlusal to the cement-enamel junction^(5,11). The buccal cusp was reduced 1.5 mm occluso-cervically and 1 mm bucco-palatally placing the margin away from the occlusal contact and grooves^(12,13). Proximally, the preparation was extended without destroying the contact area which represents the area of highest contour. Where possible, all the preparations were confined within the enamel. However, the exposure of some dentin often occurred, especially in the cervical tooth region. This not only produces a highly predictable and stable bond, but also the enamel provides stiffness to the tooth. In the absence of surface enamel, the tooth may be more prone to flexure during loading which may cause fatigue and eventual fracture of laminate^(3,14).

After that, all the line angles were rounded with white stone using slow speed handpiece. Hand chisel (Hu-Friedy) was used for margin finishing. Finally the preparation was checked with the previously prepared silicone index from the lateral view to ensure that the necessary reduction of the facial surface was done properly^(6,15) as shown in (Fig. 2).

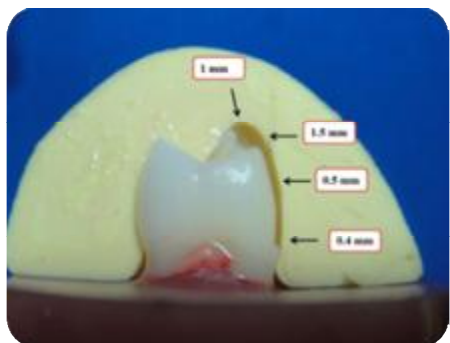


Figure 2: Silicone index to ensure consistent facial and occlusal reduction.

Final impression was taken for all teeth in group B, C and D with addition silicone impression material using two-stage putty-wash technique. Each impression was boxed using sheet wax and poured with type III dental stone (Zhermack, Italy). After setting, the die was trimmed and numbered according to its respective tooth.

Group A: restored with direct composite veneers using Filtek Z250 XT. The prepared tooth was cleaned with fluoride-free pumice using polishing cup and then etched with 35% phosphoric acid (Scotchbond™ Etchant, 3M ESPE, USA) for 15 seconds, rinse for 10 seconds and air dried gently for 5 seconds according to manufacturer's instructions. Immediately after drying, two consecutive coats of adhesive (Adper™ Scotchbond™ 1 XT, 3M ESPE, USA) were applied with gentle agitation for 15 seconds using a fully saturated brush, the adhesive then was gently air thin for 5 seconds to evaporate solvent and light-cure with LED curing light (Woodpecker, China) for 10 seconds according to manufacturer's instructions. The buccal third (bucco-palatal) of the template was then packed with the composite material and the template was seated on the tooth. The excess composite extruded from the hole was removed and the composite was light-cured using LED curing light positioned closed to the tooth for 20 seconds according to manufacturer's instructions. After removing the template, the veneer was finished and polished using Optidiscs finishing and polishing system (Kerr, Switzerland).

Group B: restored with indirect composite veneers with Filtek Z250 XT. After fabrication of the stone die, two coat of die spacer was applied with a brush on the prepared part of the die (1 mm) away from the margins⁽⁵⁾. Standard thickness of the laminates in the original form of the teeth was achieved using the previously prepared copyplast template in the same manner used for direct composite and light cured for 10 seconds. After that, the veneer was removed from

the tooth and light cured for another 10 second according to manufacturer's instructions. The thickness was checked with measuring device. Finally the veneer was placed on the prepared tooth and the margins were checked with dental explorer. After optimal fitness had been verified, the veneers were finished and polished with Optidiscs and prepared for cementation (Fig. 3).

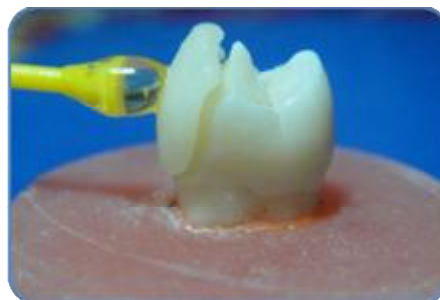


Figure 3: Checking the fitness of the indirect composite veneer on the tooth.

Group C and Group D: restored with CAD/CAM veneers (IPS e.max CAD and Lava Ultimate Restorative blocks respectively). The veneers were completed in four phases. Firstly, in "ADMINISTRATION" phase, veneer was selected as restoration type from single restoration options. Maxillary first premolar tooth was selected as abutment tooth, "bigeneric copy" was chosen as the mode of design and the type of materials and manufacture (IPS e. max CAD or Lava Ultimate Restorative) was defined. Secondly, in the "SCAN" phase three dimensional images were obtained by scanning the models by inEos Blue scanner (Sirona Dental Systems, Bensheim, Germany). Biocopy was taken first by scanning the primary model from buccal, mesial, and distal side to obtain three image for each model, then the scanning of the die was accomplished by rotational scan in which the die was fixed on the rotation mouse at 60°, which automatically takes 8 snap shot for each die model, then only 3 image were chosen. After that, both scans were automatically analyzed and correlated with each other by the system which allows alignment of the 3-dimensional image of the primary models on top of the 3-dimensional image of dies correctly. The designing of veneer was then started in "MODEL" phase with preparation trimming by hiding image regions outside the preparation, the margin of preparation was automatically detected by the system (Fig. 4) and in copyline section, and the area to be copied from the biocopy was delineated in order to design a laminate veneer identical to the original tooth form.

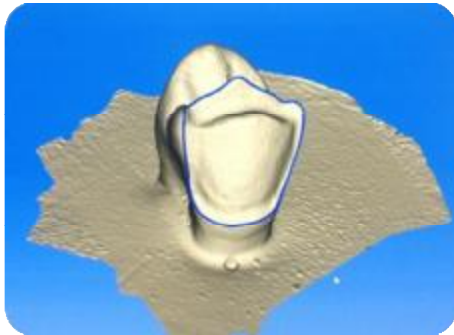


Figure 4: Automatic preparation margin detection.

After that, other veneer parameter was defined in "DESIGN" phase such as minimum veneer thickness (0.4 mm) and spacer (8 μm) which were determined according to manufacturer's instructions.

The milling process of the samples started as follows: a) the selected ceramic block (IPS e.max CAD or Lava Ultimate Restorative) was inserted in the spindle of the milling chamber of the CEREC in-lab machine and fastened with the set screw. B) The milling process was fully automated without any interference with the two diamond cutting instrument acting together simultaneously in the shaping process, with copious water cooling sprayed from both directions. C) After completion of the milling process, the restoration was separated automatically.

According to manufacturer's instructions, The Lava Ultimate Restorative veneers didn't require any further firing or glazing, while the IPS e-max CAD ceramic laminates, appear to be in their pre crystallized format after milling where they have the bluish-gray color. They were fired in a short 30 minutes firing cycle in a ceramic sintering furnace (Ivoclar/Vivadent/technical, Germany) according to manufacturer's instructions.

The internal bonding surface of indirect veneers was treated according to their manufacturers' instructions as follow:

a) Indirect composite veneers (Group B) were sandblasted with 50 μm Al_2O_3 particles for 10 second at maximum pressure of 2 bars (30 psi), and then cleaned by ultrasonic cleaner with distilled water for 5 minutes.

b) IPS e.max CAD veneers (Group C) was acid etch with 5 % hydrofluoric acid gel (IPS Ceramic Refill) for 20 seconds washed and thoroughly with air/water spray for 30 seconds according to the manufacturer instructions⁽⁷⁾. The veneers then silanated with RelyX Ceramic Primer (3M ESPE, USA) which was brushed onto the internal surface of the veneer and lightly air-dried for 5 seconds to evaporate the solvent.

d) Lava Ultimate CAD/CAM Restorative veneers (Group D) were cleaned in an ultrasonic cleaner with distilled water for 5 minute using distilled water. Then sandblasting was done following the same protocol used with indirect composite. The veneers were then cleaned with alcohol and dried with air according to manufacturers' instructions. The RelyX Ceramic Primer was applied in the same manner as described previously for IPS e.max CAD.

All indirect veneers were cemented by the 3M RelyX veneer cement using two-steps etch and rinse technique and the translucent shade cement. For easier handling, the veneers were held by Optrastick during cementation procedure. The same procedure was followed for all indirect veneer according to the manufacturer's instructions of the cement. The veneers were then stored in distilled water at 37° for 2 weeks before testing.

The fracture strength test performed using a Universal Testing Machine (LARYEE universal testing machine, China). Load was applied at a crosshead speed 0.5 mm/min⁽⁵⁾ with a customized plunger (steel rod with a flat end 3.6 mm diameter) attached to the upper movable compartment of the machine⁽⁷⁾, placed at the occlusal part of the laminate veneer⁽¹⁶⁾. The load was applied at 45° to the long axis of the tooth⁽¹⁷⁾. This orientation was standardized with a specially designed, locally manufactured, mounting jig (Fig. 5). The maximum load to produce fracture for each sample was automatically recorded in Newton (N) using computer software. Modes of failure were assessed with stereomicroscope at 20x magnification. The results of this study were analyzed with one-way ANOVA and LSD test.



Figure 5: Load application at 45° to the long axis of the tooth.

RESULTS

The means and standard deviations of fracture strength were calculated for each group shown in (Table 1).

Table 1: Descriptive Statistics: Mean and standard deviation of fracture strength in Newton.

Groups	No.	Mean	SD
Control	10	420.80	53.549
Group A	10	336.80	71.194
Group B	10	272.80	35.279
Group C	10	226.60	60.588
Group D	10	271.80	68.796

The results of this study showed that the highest mean of fracture strength was recorded for the control group (420 N), followed by group A (336.8 N), next group B and group D (272.8 and 271.8 N) respectively, while the lowest mean value of fracture strength was recorded by group C as shown in (Fig. 6).

ANOVA test revealed statistically highly significant differences among the five groups (Table 2).

Table 2: Comparison among the groups using one-way ANOVA test

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	227036.32	4	56759.08	16.139	.000
Within Groups	158260.80	45	3516.907		

Table 3: Multiple Comparisons LSD test

Groups	Mean Difference	Sig.	
Control group	Group A	84.00*	.003
	Group B	148.00*	.000
	Group C	194.20*	.000
	Group D	149.00*	.000
Group A	Group B	64.00*	.020
	Group C	110.20*	.000
	Group D	65.00*	.018
Group B	Group C	46.20	.088
	Group D	1.00	.970
Group C	Group D	-45.20	.095

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

The results of LSD test showed that there were statistically highly significant differences ($p < 0.01$) in the fracture strength of control group as compared with the all experimental groups (A, B, C and D), also statistically highly significant difference was found between group A and group. Additionally, there were statistically significant differences in fracture strength between group A and group B and between group A and group D.

On the other hand, no statistically significant differences were found among all indirect veneers groups (Group B, C and D).

DISCUSSION

According to the results of this study, the control group presented the highest mean fracture load among the groups, these results come in agreement with the results of Prasanth⁽¹⁸⁾ and Akoğlu and Gemalmaz⁽⁵⁾, and the differences between control group and other test groups were found to be statistically highly significant.

The next higher mean of fracture strength was recorded by group A, this may be due to the formation of a continuum between tooth surfaces, adhesive, and restorative material, which is accomplished by the demineralization and penetration of resin in enamel and the formation of a unique body between restoration and tooth structure⁽¹⁹⁾.

In comparison between the mean of the directly restored group and the indirectly restored groups, the mean of fracture strength of direct composite veneer (Group A) was statistically significantly higher than that of groups restored with indirect technique (Groups B, C, and D), this could be explained by the elimination of cement layer in the direct composite veneer as cement is considered the weak restorative link⁽²⁰⁾. Composite luting materials are vulnerable to water sorption, polymerization shrinkage, and microleakage⁽¹⁴⁾. This finding comes in agreement with Duzyol et al.⁽²¹⁾ results.

In spite of the fact that the same composite resin material was used for direct and indirect laminate veneers fabrication and exhibits similar flexure strength, flexure modulus and hardness, the fracture strength of group B was found to be significantly lower than that of group A. This result may be attributed to the effect of surface conditioning (sandblasting and ultrasonic cleaning) of the indirect composite veneer prior to cementation in addition to the presence of the weak cement interface. This result comes in agreement with Borba et al.⁽²²⁾ and Duzyol et al.⁽²¹⁾ who found statistically highly significant different between fracture strength of directly and indirectly fabricated composite veneers. While disagree with Gresnigt and Özcan⁽¹¹⁾ who found that direct and indirect resin composite laminate veneers showed comparable mean of fracture strength, owing to the difference in materials used for the construction of direct and indirect composite veneers.

According to LSD test there was a statistically highly significant difference between group A and group C, as composite materials have shown a greater capacity to absorb compressive loading forces and reduce the impact forces by 57% more than porcelain⁽²³⁾. However, this result disagree with the results Batalocco et al.⁽⁹⁾ study in which

they found that there was no significant difference in fracture strength between composite resin veneers and porcelain veneers. This may be due to the difference in the test condition as they performed testing of the restorative materials under the wet condition.

On the other hand, the statistically significant difference found between groups A and D may be, in addition to the weak cement interface, due to the method of construction of Lava Ultimate Restorative blocks as it was processed multiple hours in a special heat treatment process which result in a high degree of conversion and this in turn causes improvement in mechanical strength and hardness. However, this procedure increases the cross-linking of the resin to a high extent but consequently leads to a more brittle material with higher flexural strength of (204 MPa)⁽²⁴⁾. These results disagree with the results of Duzyol et al.⁽²¹⁾ who found statistically non-significant difference in fracture strength between Lava Ultimate Restorative and direct composite veneers, which may be attributed to different luting cement (dual-cured luting cement Duo-Link Universal, Bisco) used for cementation of Lava Ultimate Restoratives veneers.

Moreover, statistically non-significant difference in the mean of fracture strength obtained from group B and group D that have been recorded approximate means of fracture strength of (272.8 N) and (271.8 N) respectively. This could be attributed to the comparable properties of both materials; Filtek Z250 XT has compressive strength of (380 MPa) and modulus of elasticity of (12.5 Gpa), Lava Ultimate Restorative has a compressive strength of (383 MPa) and a modulus of elasticity of (12.7 GPa). This may be explained by the fact that both materials have same percentage of filler loading about (80% wt), which composed mainly of zirconia/silica nanoclusters. Also both materials were subjected to comparable surface treatments. This is come in agreement with Duzyol et al.⁽²¹⁾.

The lowest mean of fracture strength presented by group C (226.6 N), this could be attributed to the combination of high strength (360 MPa) combined with high modulus of elasticity (95.5 GPa)⁽²⁵⁾ which translates to lower resiliency, which is the capability of the material to absorb energy when it is deformed⁽²⁶⁾. So this might result in load transition to the weak link of the restoration (the cement layer)⁽⁴⁾. This result agrees with Khatib et al.⁽⁷⁾ who recorded a mean of fracture strength (255 N) for IPS e.max CAD.

The fracture strength values obtained for teeth restored with indirect composite and nano resin ceramic veneers confirm the theory that polymer

materials have greater capacity to distribute tensions in a more homogeneous way than ceramics as they present greater resiliency resulting in a larger capacity to suffer plastic deformations, preserving the adhesive interface. Another important aspect that explains this point is the synergism of behavior among the indirect resins, resin cement and adhesive system, which have similar compositions and high bond capacity among themselves⁽²⁷⁾.

However, according to LSD test, the difference in fracture strength between all indirect groups (group C, B and D) was statically non-significant, which comes in agreement with the results of Carneiro et al.⁽²⁸⁾ who found comparable fracture strength for both IPS e.max CAD and Lava Ultimate Restorative. This is also come in agreement with Duzyol et al.⁽²¹⁾ who found non-significant difference between indirect composite and Lava Ultimate Restorative veneers. However, this finding disagrees with the results of DE Goes⁽²⁹⁾ who compared the fracture strength of disc shape specimens of 0.5 mm thickness fabricated from IPS e.max CAD and Lava Ultimate Restorative and conventional composite materials and found that Lithium disilicate glass-ceramic for CAD demonstrated the highest strength.

Failure analysis of the fractured laminates in this study showed mainly fracture of the veneer restoration followed by veneers debonding which coincides with the finding of Gresnigt and Ozcan⁽¹¹⁾. Clinically, these types of failure could be considered more favorable, since it allows intraoral repair options. Fracture of veneers was observed in 100% in groups (A, B, D) as the dominant type of fracture. Fracture of the laminate veneer was attributed first to the good adhesion of the laminate veneer to either dental tissue or the cement layer⁽⁸⁾. Another explanation for this could be the relatively lower flexure strength of the materials, based on the fact that if the flexural strength of the veneer cannot protect the tooth, the veneer will fracture before the loading force is transferred to the tooth⁽¹⁴⁾. On the other hand a lower modulus of elasticity correlates to increased deformation under load, suggesting that Lava Ultimate Restorative and Filtek Z250XT were more likely to absorb the stress than silica based-ceramics⁽³⁰⁾.

Debonding of laminate veneers, on the other hand, showed the weak link between the cement/tooth and the laminate veneer and was observed only in IPS e.max CAD group with 100 % as the only mode of failure. This could be attributed to the lower resiliency of the material which results in high stresses that develop directly

below the loaded area at the cement interface. Interfacial stresses arise because ceramic has a higher elastic modulus than the tooth or cement⁽¹⁴⁾.

A higher incidence of bond failure was observed at cement/veneer interface 70% and the remaining 30% of debonding was at tooth/cement interface due to compromised bonding between the resin cement and the intaglio surface of the veneers. In other words most failures are caused by complete debonding at the porcelain/cement interface. Even though the highest bond strength for lithium disilicate IPS e. max CAD is achieved when it was hydrofluoric acid-etched after being machined, compared to being machined only or machined/grit blasted. However, hydrofluoric acid-etched silica-based ceramic has a highly retentive high-energy surface which is highly susceptible to contamination⁽³¹⁾. This makes the pretreated ceramic bonds negatively influenced by external factors such as water absorption, changes in temperature, and contamination by latex gloves, saliva, and the fit checker⁽³⁰⁾. Also it has been found that hydrofluoric etching generates a significant amount of crystalline debris that contaminates the porcelain surface and may reduce bond strength by 50% and this may be considered as another explanation for the lower bond strength at cement/ veneer interface⁽³²⁾.

The results of the current study exhibited mean values for the experimental groups ranging between (226.6 N) for IPS e.max CAD veneers and (336.8 N) for the direct composite veneers, while the natural tooth biting force was about (250 N) for the first premolar as a single tooth bite force measured in healthy young adults⁽³³⁾. On the other hand others investigators assumed (170 N) as the chewing force for premolars and 500 N was assumed as the heavy parafunctional load of bruxism and traumatic occlusion⁽³⁴⁾. This indicates that both techniques direct and indirect and all the three different materials used for fabrication of laminate veneers could be considered strong enough to withstand normal biting forces in the premolar region, but for patients with parafunctional habit other treatment modality should be considered. Further investigation is required to study bonding of IPS e.max CAD veneers, which were least likely to fracture but the most likely to completely debond. These results may provide the clinicians a guideline for the selection of restorative treatment modality when they provide an esthetic veneer restoration for premolar. It appeared that the mechanical strength of the material would not be a determining factor, but other factors such as predictable and durable esthetics, reliability of the

bonding and/or the cost of treatment could be determining factors to select the specific restoration.

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