Evaluation of Bond Strength of Two types of Resins with Different Viscosities to Lithium Disilicate Glass Ceramic after Two Types of Surface Treatments. (In vitro study)

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Abstract

Purpose: To evaluate microtensile bond strength (µTBS) of two types of resin with different viscosities: High viscosity resin (Flowable composite) and Low viscosity resin (Light cured resin cement) With lithium disilicate discs after two types of surface treatment: Laser etching (Er,Cr:YSGG pulsed laser), hydrofluoric acid etching

Materials and Methods: Ceramic slices (n=28) were prepared from IPS Emax CAD/CAM blocks, two surface treatments were applied followed by silane primer: Er,Cr:YSGG laser (group A) and hydrofluoric acid (group B). Two self-adhesive resin cements were injected to the emax specimens using ethelyne tube: flowable composite Z350 (High viscosity resin) sub group (I), mojo veneers resin cement (low viscosity resin) (subgroup II). Thermo-cycling using THE-1100 SD Mechatronics thermocycler was done to simulate the oral cavity media, each bonded micro-cylinder assembly resin was subjected to microtensile bond strength. Data was tabulated and statistically analyzed.

Results: HF acid etching & silanation as Surface treatment had a significantly higher (mean±SD) value than Laser surface etching followed by silanation with both high and low viscosities resin. High viscosity resin (flowable composite) should higher bond strength than low viscosity resin (light cure resin cement) but it was statistically insignificant.

Conclusions: Acid etching followed by silanation had a significantly higher value than laser etching followed by silanation for both resin viscosities.

Resin with high viscosity had a higher value of micro-shear bond strength than resin with low viscosity yet the difference was not significant.

Keywords: Ceramic- Er,Cr:YSGG laser- Resin cements- Microtensile Bond Strength.
Introduction

Hot-pressed LDC consisting of a silica glass matrix and lithium oxide (Li2O) not only provides better translucency and aesthetics than zirconia ceramic but also has better flexural strength than leucite-reinforced glass ceramics [1,2].

Clinical restoration mainly depends on the bonding effect between the ceramic and resin cement rather than the strength of the ceramic [3,4].

Strong interfacial bonding between the ceramic and resin cement increases the fracture resistance[5] and marginal adaptation[6,7] and reduces the microleakage [7,8], resulting in the retention of the restoration.

Surface modification to increase the roughness or to form specific chemical bonds is of great importance for increasing interfacial bonding.

However, due to the relatively low strength, LDC usually suffers from serious surface damage introduced by traditional sandblasting abrasion, leading to a decrease in flexural strength [9,10].

Hydrofluoric acid (HF) treatment is considered as a relatively mild method to chemically modify LDC [11,12]. HF can etch the surface to create an irregular microstructure on the surface [13], resulting in a high specific surface area that increases the bonding area at the interface [14,15].

Lasers have been introduced during the last decade as an alternative to traditional methods for ceramic surface treatment. Numerous works have investigated the effects of CO2 lasers in continuous or long pulse mode, on shear bond strength of ceramic to other substrates [16,17]. Short pulse lasers such as Nd:YAG, Er:YAG, and Er,Cr:YSGG have also been tested [21–22]. More recently, Ti:Sapphire laser, which provides ultra-short pulses in the femtosecond range, has been introduced, and is considered an optimal alternative as it does not produce any thermal or mechanical damage to the ceramic surfaces [20,21].

However, there is some controversy about the effects of these lasers on the bond strength between ceramic materials and resin cements and composites, with different studies reporting widely differing results [22,23].

The luting material plays a major role in the aesthetic outcome of ceramic veneers, allowing good shade matching with adjacent teeth [24]. Thus, changes in the color of resin cement used for luting may become visible, affecting the final aesthetic appearance of the restoration and leading to treatment failure [25]. For the cementation of all-ceramic restorations, resin-based cements are generally used because they can be adhesively bonded to dental structures and they exhibit low solubility, good mechanical properties, and favorable aesthetics [26].

Resin cements are usually divided into three categories, according to their curing mode: chemically activated, light-cured, and dual-cured cements. Chemically activated cements are mostly employed for cementation of metallic and metal-ceramic restorations or cast posts. Light-cured cements have a more restricted indication, used only for the luting of laminate veneers.
because of the decrease in light intensity during transmission through the restoration [27]. Dual-cured cements were developed to obtain good mechanical properties and a high degree of conversion in either the presence or absence of light [28,29]. However, regarding the color stability of resin cements, for chemically activated and dual-cured materials, the oxidation of the reactive groups present in the tertiary amines may cause a color change in the cement over time [30]. The final color of thin ceramic restorations is determined by a combination of the substrate, the thickness of the ceramic, and the luting material [31,32]. Among these factors, resin cement is the one that can have the most influence on the final color of ceramic laminate veneers [33].

However, depending on the curing mode and commercial brand, cements identified with the same shade (A1, A2, translucent, bleach, etc.) do not have the same color parameters [26]. Therefore, these variations can influence the color stability of the cement and the final color of ceramic restorations [34]. It is important to note that the influence of different shades of dual-cured and light-cured cements underlying ceramic restorations and their long-term discoloration is little known. Also, this discoloration becomes much more important beneath thin-translucent ceramic veneers [30]. Because there are few studies on the long-term (more than one year) color stability of cemented thin ceramic veneers with resin cements having various shades and curing modes [35]. Furthermore, silane coupling is another effective way to increase the bonding effect by forming siloxane bonds at the interface between the ceramic and resins. Importantly, both physical interlocking and chemical bonding can decrease along with cyclic expansion and contraction at high and low temperatures. This effect with the water microleakage induced by chemical degradation at the interface might result in the separation of resin cement from the ceramic [36]. Thus, this bond strength after thermal cycling (TC) influences the longterm restoration. Despite initial progress, the bond durability between LDC and resin and systems controlled by different treatments has been seldom reported. Here in, we tried to illustrate the effect of physical and/or chemical surface treatments on bonding durability. The bond strength between LDC and two kinds of resin cements before and after thermal cycling upon a variety of surface treatments including HF.

2. Materials and Methods
I. Materials:
Brand name, material description, manufacturer and lot number are listed in table (1).
EVALUATION OF BOND STRENGTH OF TWO TYPES OF RESINS WITH DIFFERENT VISCOSITIES TO LITHIUM DISILICATE GLASS CERAMIC AFTER TWO TYPES OF SURFACE TREATMENTS. (IN VITRO STUDY) | Haitham Tohamy et al Dec 2020

**Table (1):** List of materials & equipments used.

| Brand name | Material description          | Manufacturer       | Lot #     |
|------------|------------------------------|--------------------|-----------|
| 1          | IPS e-max lithium disilicate glass ceramic | Ivoclar vivadent | X52446    |
|            | Mojo veneer light cure resin cement | Light cure resin cement | 6956590   |
| 4          | Flowable composite Filtek Light cure High viscosity resin | 3m | Na36575   |
| 5          | Bisco porcelain etchant Hydrofluoric acid | Bisco, Inc. Schaumburg,IL60193 | 1900004495 |
| 6          | Bisco silane primer Pre hydrolyzed Porcelain silane | Bisco, Inc. Schaumburg,IL60193 | 1900006365 |

**Samples grouping:**

Twenty eight specimens of final dimensions of 14 mm x12mm and 0.5 mm thickness fabricated.

**Sampling:**

Specimens were divided into two groups according to the type of surface etching:

**Group A:** Laser etching. (n=14)

Done using Er,Cr:YSGG laser irradiation (Millenium;Biolase Technology, Inc., San Clemente, CA,USA) with a 2.78 μm wavelength, pulsed laser-powered hydrokinetics, and energy parameters of 300 mJ at 2.5W, respectively. The air and vapor will be adjusted to 50% of the laser unit. The optical fiber of the laser (400μm diameter, 4 mm length) will be aligned perpendicular to each specimen at a distance of 1 mm and will be moved manually in a sweeping fashion over the entire area during a 60 seconds exposure period.

**Group B:** Acid etching. (n=14)

Done using hydrofluoric acid 9.5% for 20 sec.

Each group was subdivided into two subgroups according to the type of cement viscosity used:
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Table (2): Sample grouping.

| Surface Treatment Type of Cement | Laser Etching Group A | Acid Etching Group B | Total Number of samples |
|----------------------------------|-----------------------|----------------------|-------------------------|
| Flowable composite (High viscosity resin) Sub group I | AI N=7 | BI N=7 | N=14 |
| (Mojo veneer Resin cement) Sub group II | AII N=7 | BII N=7 | N=14 |
| Total Number of samples | N=14 | N=14 | N=28 |

Subgroup I: Flowable composite (high viscosity resin) (n=7)
Subgroup II: Mojo veneer resin (low viscosity resin) (n=7)

III. Preparation of the specimens:

Blocks of CAD CAM esthetic restorative materials (IPS Emax) were used to prepare slices with the following dimensions: 14mm x 12mm x 0.5mm for Using IsoMet 4000 microsaw with cooling water system, by a dindom disk 0.6 mm thickness with cutting speed 2500 rpm. Then each ceramic disc was examined with a Caliber and digital caliber to make sure they all had the same thickness 0.5 mm each.

Surface Treatments:

For easier handling and fixation during the micro shear test, a number of 28 slices of Emax were embedded in an acrylic blocks, before any surface treatments.

To easily differentiate between the two surface treatment techniques during the rest of the procedures, two different color coded acrylic resin blocks were selected. white color was used for laser surface treatment and Green color for acid surface treatment.

Then each acrylic block was given the Initial letter related to the type of resin.

Before any surface treatments done, 70% ethyl alcohol was used on each of 28 slices for cleaning the surface from any debris and drying these surfaces very well.

1) Hydrofluoric Acid Etching + Silane:

Fourteen of the Emax ceramic slices embedded in acrylic blocks carrying BI & BII initials were etched using Hydrofluoric acid 9.5% for 20 seconds afterwards washed and air-dried with oil-free air/water syringe.

Silane coupling agent was applied for 60 seconds. Then air drying was done for the specimens using oil free air way syringe.

2) Laser etching + silanation:

The ceramic slices were subjected to laser irradiation followed by the application of silane primer. In this group Er,Cr:YSGG laser with wave length 2780nm, pulsed lased-powered hydrokinetics, was used. Vapor and air were adjusted to 50% of the laser unit.

The optical fiber of the laser unit were 400µm in diameter and 4mm in length, arranged perpendicular at distance≈ 1mm over each ceramic slice and moved manually in a sweeping manner to cover all the surface area during the adjusted exposure period. The laser parameters were adjusted so that, the power was 2.5 W for Al & AlII acrylic blocks carrying Emax slices.

The repetition rate was 20 Hz for 60 seconds at surface of the slices those specific laser parameters where chosen according to Pinar Kursoglu, et al in 2013 (74). The slices were then rinsed with distilled water and air dried. Silane primer was then applied to the irradiated surfaces for 60 seconds and then air dried for 60 seconds.

IV) Application of resin cement material:

Emax slice Received 5 resin micro cylinders. Irisies of polyethylene tube having 1mm diameter and 1mm height
(fig15) were positioned over the disc surface, then cement was injected into the tubes through the mixing tip, light curing was done through the tube for 20 seconds, with a LED light-curing unit* with an irradiance of 1200 mW/cm² according to the manufacturer’s instructions. Polyethylene tube irises were not removed in order not to subject the resin micro cylinders to shear stress at the interface, and to eliminate any pretest failures according to Andrade et al. (2012)

V) Thermocycling:

In order to simulate the oral cavity media, specimens were thermo-cycled using THE-1100SD Mechatronics thermo-cycler between 5 °C and 55 °C for 5000 cycles with a 20 seconds dwell time and 5 seconds transfer time.

VI) Micro-Shear Bond Strength Test:

Each block with its own bonded micro-cylinders was secured horizontally with tightening screws to the lower fixed compartment of a universal testing machine* with a loadcell of 5 kN and data were recorded using computer software**.

3. Results

1. Descriptive statistics:

Table (7): Descriptive statistics for micro-shear bond strength (Mpa) for different groups

| Surface treatment | Resin cement | Mean   | Std. Deviation | Median | Range      |
|-------------------|--------------|--------|----------------|--------|------------|
| Laser etching     | High viscosity | 13.51  | 5.24           | 12.70  | 19.08      |
|                   | Low viscosity | 12.58  | 4.84           | 11.06  | 16.98      |
| Acid etching      | High viscosity | 21.80  | 5.86           | 20.93  | 18.44      |
|                   | Low viscosity | 18.39  | 5.34           | 18.85  | 15.00      |

* Elipar S10, 3M Espe, St. Paul, MN

** (Instron® Bluehill Lite Software)
2. Effect of different variables and their interaction:
   Only type of surface treatment had a significant effect on micro-shear bond strength (p<0.001).
3. Main effects:
   A-Effect of Surface treatment:
      Acid etched samples (20.09±5.78) had a significantly higher value than laser etched samples (13.04±4.98) (p<0.001).
   B-Effect of resin viscosity:
      Resin with high viscosity (17.65±6.90) had a higher value of micro-shear bond strength than resin with low viscosity (15.48±5.81) yet the difference was not significant (p=0.120).
4. Interactions:
   1-Effect of type of resin cement viscosity within each Surface treatment:
      ➢ Laser etching:
         Resin with high viscosity (13.51±5.24) had a higher value of micro-shear bond strength than resin with low viscosity (12.58±4.84) yet the difference was not significant (p=0.634).
      ➢ Acid etching:
         Resin with high viscosity (21.80±5.86) had a higher value of micro-shear bond strength than resin with low viscosity (18.39±5.34) yet the difference was not significant (p=0.085).
   2-Effect of Surface treatment type within each resin viscosity:
      ➢ High viscosity:
         Acid etched samples (21.80±5.86) had a significantly higher value than laser etched samples (13.51±5.24) (p<0.001).
      ➢ Low viscosity:
         Acid etched samples (18.39±5.34) had a significantly higher value than laser etched samples (12.58±4.84) (p=0.004).
II-Mode of failure
After testing mode of failure three patterns were revealed:
1-Mode of failure in different surface treatments:
   Frequencies (n) and Percentages (%) of mode of failure in different surface treatments were presented in table (12) and fig. from (29) to (31)
   There was a significant difference in the distribution of different modes of failure within samples subjected to different surface treatments (p<0.001). For laser etching, most of the samples had an adhesive mode of failure 49 (70.0%), lower percentage had mixed failure mode 21 (30.0%) while there was no samples with a cohesive mode of failure. For acid etching, most of the samples had a cohesive mode of failure 56 (80.0%), lower percentage had mixed failure mode 14 (20.0%) while there was no samples with an adhesive mode of failure.
2-Mode of failure within each type of cement:
   ➢ High viscosity
      Majority of samples cemented with high viscosity resin cement 32 (45.7%) had a cohesive mode of failure, while most of the low viscosity samples 29 (41.1%) failed adhesively, yet the difference between both groups was not significant (p=0.259).
   3-Mode of failure within each type of cement:
      ➢ High viscosity
      There was a significant difference in the distribution of different modes of failure within samples subjected to different surface treatments (p<0.001). For laser etching, most of the samples had an adhesive mode of failure 20 (57.0%), lower percentage had mixed failure mode 15 (42.9%) while there was no samples with a cohesive mode of failure. For acid etching, most of the samples had a cohesive mode of failure 32 (91.4%), lower
percentage had mixed failure mode 3 (8.6%) while there was no samples with an adhesive mode of failure.

- **Low viscosity**

  There was a significant difference in the distribution of different modes of failure within samples subjected to different surface treatments (p<0.001). For laser etching, most of the samples had an adhesive mode of failure 29 (82.9%), lower percentage had mixed failure mode 6 (17.1%) while there was no samples with a cohesive mode of failure. For acid etching, most of the samples had a cohesive mode of failure 24 (68.6%), lower percentage had mixed failure mode 11 (31.4%) while there was no samples with an adhesive mode of failure.

4. Mode of failure within each surface treatment:

- **Laser etching:**
  
  Majority of samples of both types of resin cement failed adhesively, with low viscosity cement 29(82.9%) having a significantly higher percentage (p=0.036).

- **Acid etching:**
  
  Majority of samples of both types of resin cement failed cohesively, with high viscosity cement 32(91.4%) having a significantly higher percentage (p=0.034).

4. Discussion

Recently, the revolution in dental ceramics in respect to microstructure, optical properties and mechanical properties offered wide range of indications, moreover the increase in demand and interest in achieving ultimate esthetic paved the way to the use of ceramic restorations in anterior zone.\(^{147}\)

The clinical success and long-term intra-oral survival of different indirect ceramic restorations relay mainly on achieving a strong and durable bond between substrate and resin cements that can provide an impregnable seal \(^{148}\). Resin cements were used with ceramics restorations not only for providing the bond strength needed, but also to strengthen the brittle ceramics materials.

The main concern of bonding ceramic restorations to tooth structure is the bond strength at the two interfaces: tooth/resin interface and ceramic/resin interface, as the weak bond at any interface will significantly affects the final bond strength so affecting the clinical success of the ceramic restoration.\(^{149}\)

**Discussion**

Due to its optical properties and strength properties, lithium di-silicate was selected in this study, allowing it to be used in thin sections without affecting both esthetically and functionally the final results.

The properties of a luting agent and the surface treatments for ceramic surfaces before cement application play a major role in the clinical success of many indirect ceramic restorations.

Selection of the luting agent assumes to be significant factor while bonding to indirect restorations. Resin cements provide ceramic materials with both the strength needed for these brittle materials, and a secure seal between the restorations and tooth structure. Two types of resin-composite cements were used in this study to evaluate their bond strength.

Light cured resin luting material enables a simplified bonding technique and also provides the cured cement with excellent colour stability. For highly esthetic veneer restorations, this feature is vital. Most ceramic and composite veneers are sufficiently thin and translucent to allow adequate penetration of light through the veneer to cure the cement completely.\(^{37}\)

Composite resin is a widely used material for the direct restoration of anterior and posterior teeth. Due to their advantages in terms of mechanical properties and extended
handling time, in early days Besek et al.\textsuperscript{(38)} were the first to recommend composite resin for the luting of CEREC ceramic inlays as well. At that time, this CAD/CAM system was rather inaccurate so the use of a resin composite as a luting agent was an efficient solution to protect restoration margins from micro leakage, esthetic defects, and caries.

Light cured self-adhesive flowable composite that contains photosensitive aliphatic tertiary amine initiator, with high filler content and (UDMA) content in its matrix replacing (TEGMA) which is the main reason of water sorption.

Different surface treatments were applied in this study on the CAD/CAM material surface to be evaluated and tested, these surface treatments include: acid etching (9.5\% buffered hydrofluoric acid) followed by silane primer, & laser etching using Er,Cr:YSGG pulsed laser followed by silane primer.

The first applied surface treatment was hydrofluoric acid etching. As acid etching is the most commonly employed technique to improve the bond strength. The HF surface treatment modifies the microstructures of CAD/CAM ceramic surface by partial dissolution of the glassy phase of the ceramic, forming micro porosity on the ceramic surface.\textsuperscript{(39)} it increases the surface area by creating micro-pores into which uncured flowable resin penetrates to provide durable micro-mechanical interlocking.\textsuperscript{(40)}

The second applied surface treatment was laser etching, the ceramic slices were subjected to laser irradiation followed by the application of silane primer. In this group Er,Cr:YSGG laser (Water lase i Plus; Biolase Technology Inc., Irvine, CA, USA) with wave length 2780\text{\textmu}m, pulsed lased-powered hydrokinetics, was used. as ER:YAG (erbium: yttrium, aluminum, garnet) laser was reported to remove the glass phase of the ceramic creating rough surface suitable for bonding to the resin cement, Vapor and air were adjusted to 50\% of the laser unit. The optical fiber of the laser unit were 400\text{\mu}m in diameter and 4\text{mm} in length, arranged perpendicular over each ceramic slice and moved manually in a sweeping manner to cover all the surface area during the adjusted exposure period using Power of 2.5 W, with repetition rate of 20 Hz for 60 seconds at approximately one mm distance from the surface of the slices. The slices were then rinsed with distilled water and air dried then Silane primer was applied to the irradiated surfaces for 60 seconds and air dried for 60 seconds. This protocol coincides with Pinar Kursoglu, \textit{et al, in 2013}\textsuperscript{(42)}.

Since restorations normally fail after being aged in a humid and thermally dynamic oral environment\textsuperscript{(43)} so in attempt to simulate bonded restorations in the oral cavity we used thermal cycling as an artificial aging method of dental materials, and thermal strain which is simulated on the bonding surface by influence of liquids and thermal change.\textsuperscript{(44)} So In our present study, aging protocol was applied on all specimens, it was done through thermocycling after surface treatments were done and resin was applied. It was done to simulate the oral cavity environment after cementing the restoration using light cured resin.

Under thermal aging, the bond strength is affected by several factors including temperature settings, dwell time, and the number of cycles, in which the latest is the
most influential factor. Mean while in our study The aging protocol was done after application of surface treatments and resin micro-tubes positioned. A total of 5000 thermal cycles were done, which simulates 6 month of in vivo function. Temperature between 5°C and 55°C with 20 seconds dwell time and 5 seconds transfer time. This aging protocol was also used by Al-Thagafi in 2016.

After finishing the aging step through thermo-cycling, specimens were ready for testing its bond strength, using micro-shear bond strength test (μ-SBS test), Which is considered a relatively simple test that permits efficient screening of adhesive protocols, regional and depth profiling of a variety of substrates.

Most micro-shear studies use polyethylene tubes as molds, which are then filled with a resin composite. After water storage for 24 h, in other studies the operator uses a scalpel blade to remove these tubes manually, resulting in cylindrical composite specimens. The pressure exerted on the blade by the operator in order to cut and remove the polyethylene tubes may be transferred to the resin cylinder and consequently form cracks along the specimen. Therefore, it is fair to hypothesize that micro shear specimens may fail under relatively low loading levels or fail prematurely due to propagation of these cracks.

For this reason in the present study, the polyethylene tubes irises were not removed in order not to subject the self adhesive resin cement micro cylinders to shear stresses at the interface and to eliminate any pretest failures according to Andrade et al. in 2012.

In this study it was found that using hydrofluoric acid 9.5% conc. As a surface treatment for lithium di-silicate based ceramics recorded a significantly higher bond strength values, and this result was in co-ordination with Cengiz-Yanardag etal in 201, who concluded that prior to bonding, HF acid treatment is the best surface treatment method regarding the bond strength followed by silane application for all CAD-CAM restorative materials as examined.

In addition to the traditional surface treatments that were used to increase the Bond Strength between the ceramic surface and resin cement, in the present study, we aimed at evaluating the effect of laser irradiation on Bond Strength; however, there have been few studies on laser irradiation.

Laser surface etching followed by silane application, The majority of the previous studies evaluated the effect of erbium:yttrium-aluminum-garnet (Er:YAG) and neodmium:yttrium-aluminum-garnet (Nd:YAG) lasers on zirconia ceramics and have demonstrated controversial results. Er, Cr:YSGG laser irradiation shows its effect on hard and soft tissues through the interaction of laser energy with atomized water droplets on the tissue interface, resulting in micro-explosions and ablation of the tissue. Therefore, the effect of Er, Cr:YSGG laser on different restorative materials might vary due to the water content of the restorative materials.

In this study it was found that using hydrofluoric acid 9.5% conc. As a surface treatment for lithium di-silicate based ceramics recorded a significantly higher bond strength values than those obtained from ones treated with er:Cr laser... regardless to the type of cement used;

The results obtained in the present study are in agreement with Kursuoglu et al. [55], who reported that laser irradiation led to higher Bond Strength in the bonding between IPS Empress II and resin cement compared to a control group but to lower Bond Strength compared to that achieved through acid
etching. Additionally, the high laser power output appears to weaken the bonding between full ceramic restoration and resin cement [56].

One more interpretation was described by Cengiz-Yanardag et al in 2018 [50] who found that the low bond strengths resulting from laser surface treatment may be due to thermal surface damage caused by laser power settings, on the contrary, this disagreed with the results from others Haluk Baris Kara et al [23] in 2012 and Barutcigil et al in 2019 [22]. These differences may be attributed to the lower repetition rate which is 10 HZ in addition to that this studies didn’t apply thermocycling measures to simulate oral cavity conditions, so may be those were the reason for the difference between the two studies’ results.

It also was found that flowable composite had an insignificant higher bond strength than mojo this may be attributed to the higher mechanical prop. Of the high visc. Comp

This was in agreement with Tissiana Bortolotto et al. [57] who found The least amount of residual UDMA monomer was observed in the micro hybrid composite resin. Due to an increased filler level in composite resin and concluded that Hybrid composite showed the best results in terms of shrinkage development and stability against leaching. Shrinkage values of the self-adhesive cement tested (self-cured or light cured) were higher than those observed for the hybrid composite.

5. Conclusions

Within the limitation of this in Vitro study it was concluded that:

1) Acid etching followed by silanation had a significantly higher value than laser etching followed by silanation for both resin viscosities.

2) Resin with high viscosity had a higher value of micro-shear bond strength than resin with low viscosity yet the difference was not significant.

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