Original Article

Comparative evaluation of the shear bond strength of lithium disilicate veneers using one light-cure and two dual-cure resin cement: An *in vitro* study

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Abstract

Aim: The present *in vitro* study aimed to comparatively evaluate the shear bond strength (SBS) of one light-cure and two dual-cure resin cement to bond lithium disilicate veneers.

Materials and Methods: Thirty maxillary central incisors (n = 30) were procured and randomly divided into three groups of adhesive/resin cement systems, into groups of 10 each (n = 10); Group A: Adper Single Bond 2/RelyX Veneer Cement, Group B: Prime and Bond NT/Calibra, and Group C: Excite DSC/Variolink II. All the tooth samples were etched and respective bonding agent was applied. Similarly, all the laminate veneer specimens were etched, silanated, and treated with respective bonding agents before cementation with the respective resin cement. The SBS was measured in a universal testing machine with a cross-head speed of 1 mm/min.

Statistical Analysis: Data obtained were analyzed using the one-way analysis of variance and *post hoc* Tukey's test at a 5% significance level.

Results: The highest SBS was demonstrated by Group C (18.8 ± 0.92 Mpa), followed by Group B (18.4 ± 0.74) Mpa, and the least by Group A (17.4 ± 0.75 MPa). Significant differences were found between Group A, Group B, and Group C, respectively. However, Group B and Group C did not differ significantly from each other.

Conclusions: Dual-cure resin cement have higher SBS than the light-cure variants.

Keywords: Bonding agent; dual-cure; light-cure; lithium disilicate; resin cement; shear bond strength; veneers

INTRODUCTION

The growing advancements in the field of adhesive dentistry are resulting in a surge of individuals seeking cosmetic rehabilitation.[1,2] Porcelain laminate veneers have become increasingly popular and are used to restore discolored, worn, fractured, malformed, or slightly malpositioned anterior teeth owing to their ability to be luted adhesively ensuring a strong and secure attachment to the dental hard tissues.[3]

The clinical success of ceramic restorations depends on both the luting cement and the cementation procedure.[4,5] Several adhesive systems are available for bonding glass-based ceramic veneers to the tooth and have been investigated for their performance. However, literature is scarce in providing a consensus. Therefore, the present study aimed to comparatively evaluate the shear bond strength (SBS) of three commercially available resin cement (one light-cure and two dual-cure) in bonding lithium-disilicate (LiDiSi)-based veneers. The null hypothesis of the present study was that the SBS

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of the three types of resin cement did not significantly differ.

MATERIALS AND METHODS

Preparation of tooth samples and laminates

Following approval from the institutional ethics committee, 30 ($n = 30$) freshly extracted maxillary central incisors were procured from the department of oral and maxillofacial surgery of the dental college and hospital. The specimens were selected with an intact crown structure, fully-formed apex, free of caries, restoration, and cracks. After adequate cleaning and disinfection in a 2% glutaraldehyde solution, the tooth specimens were stored in distilled water to avoid dehydration. The labial surfaces of all the teeth specimens were flattened using a round-end tapered diamond point (TR-15, Mani Inc, Japan). The preparation was restricted to enamel, following which the teeth were cleaned with a fine flour of pumice using a rubber cup mounted on a slow-speed handpiece.

Thirty veneers were fabricated with 7 mm diameter and 1 mm thickness using LiDiSi ceramic ingots. (IPS e.max Press [Ivoclar Vivadent, Schaan, Liechtenstein]). The cameo surface was glazed, while the intaglio surface was left unglazed to facilitate adhesion to the tooth samples.

Pretreatment of the specimens

Materials used in the study is enlisted in Table 1. The tooth specimens were etched with 37% phosphoric acid gel (DeTrey Conditioner 36, Dentsply Sirona, USA) for 15 s, then thoroughly rinsed with distilled water, followed by drying. They were then divided randomly into three adhesive/resin cement groups ($n = 10$).

- Group A: Adper Single Bond 2/RelyX Veneer Cement (3M ESPE, USA)
- Group B: Prime and Bond NT/Calibra (Dentsply Sirona, USA)
- Group C: Excite/Variolink II (Ivoclar Vivadent, Schaan, Liechtenstein).

Similarly, the intaglio surface of all the 30 laminate specimens was etched with 5% hydrofluoric acid (Angelus, Brazil) for 20 s, following which it was thoroughly washed with air/water spray for 30 s and then air-dried.

Silane primer and adhesive application

Then, a silane coupling agent was applied for 1 min for the respective groups (RelyX ceramic primer for Group A, Calibra primer for Group B, and Monobond-S for Group C), then dried with a gentle stream of air. A single coat of the respective bonding agent was applied to the prepared acid-etched surface of the tooth specimens and the silane-treated surfaces of the laminate veneers, gently blown with a jet of oil-free air, and allowed to dry for 2 s. The bonding agent was left unpolymerized to avoid incongruous thickness at the tooth sample/resin cement interface.

Cementation procedure

The resin cement were mixed according to the manufacturer's instructions applied as a thin layer on the treated veneer surface and then placed slowly on the prepared tooth surface using gentle pressure. The cement was then briefly tack-cured for 5 s to facilitate the removal of the excess material and then completely polymerized using light for 40 s on each of the surfaces, i.e. buccal palatal/lingual and interproximal.

Storage and thermocycling of the specimens

The 30 bonded specimens were stored in distilled water at room temperature, 37°C for 24 h to allow cementing medium saturated with water for hygroscopic expansion. Later, the specimens were thermocycled in a thermocycling device at 5°C and 55°C for 600 cycles with a dwell time of 5 s in each bath.

Before being subjected to SBS testing in an Instron universal testing machine, the root portion of the teeth was embedded straight in self-curing acrylic resin blocks (DPI Cold Cure, Mumbai, India). The long axis of the teeth was aligned with the central axis of the acrylic block.

Shear bond strength testing procedure

The bonded specimens were placed one by one on the base of the testing apparatus (Instron Universal Testing Machine, Canton Massachusetts, USA) and kept fixed. A shear blade was attached to a holding jig placed perpendicular to the junction of the treated enamel surface and the ceramic veneer (disc-shaped). The shear force was applied parallel to the enamel flattened surface close to the bonding area [Figure 1].

For each sample, the load was gradually increased with a cross-head speed of 1 mm/min until a bond failure occurred. The values of the load at which the debonding of the specimens occurred were recorded from the display unit. The SBS was measured in newtons (N) and then converted into megapascal units (MPa). The values thus obtained were tabulated in a spreadsheet using Microsoft Excel 2019, and then, statistical analysis was carried out using Prism for Windows, Version 9.5 (GraphPad Software, La Jolla, California, USA). A Shapiro–Wilk test and a visual inspection of the histograms, normal Q-Q plots, and box plots showed that the collected data were approximately normally distributed for all the groups. Data were analyzed using the one-way analysis of variance (ANOVA) and the *post hoc* Tukey's test. The $P \leq 0.05$ was considered as the level of significance.

Table 1: Materials used in the study

Material	Manufacturer	Type	Chemical composition
RelyX veneer	3M ESPE, USA	Light-cure resin cement	bisGMA, TEGDMA, zirconia/silica, and fumed silica as fillers
Calibra	Dentsply Sirona, USA	Dual-cure resin cement	Base paste: Dimethacrylate resins, camphorquinone photoinitiator, stabilizers, glass fillers, fumed silica, titanium dioxide, and pigments Catalyst paste: Dimethacrylate resins, catalysts, stabilizers, glass fillers, fumed silica
Variolink II	Ivoclar Vivadent, Schaan, Leichtenstein	Dual-cure resin cement	Monomer matrix composed of Bis-GMA, UDMA, and TEGDMA, Inorganic fillers (silica, barium glass, ytterbium trifluoride, Ba-Al fluorosilicate glass), catalysts and stabilizers, pigments
Adper single bond 2	3M ESPE, USA	Bonding agent	Bis-GMA,2- HEMA, methacrylates, ethane, water, novel photoinitiator system, methacrylate functional copolymer of polyacrylic acid and polytechnic acid
Prime and bond NT	Dentsply Sirona, USA	Bonding agent	Di and tri methacrylate resins, PENTA nanofillers like amorphous silicon dioxide, photoinitiators, cetylamine hydrofluoride, acetone
Excite	Ivoclar Vivadent, Schaan, Leichtenstein	Bonding agent	HEMA, dimethycrylates, phosphonic acid acrylate, highly disposed silicon dioxide, initiators, and stabilizers
IPS e.Max press	Ivoclar Vivadent, Schaan, Leichtenstein	Ceramic ingots	Silicon oxide, lithium dioxide, potassium dioxide, magnesium oxide, zinc oxide, aluminum oxide, phosphorus pentoxide, and other oxides
RelyX Ceramic primer	3M ESPE, USA	Silane primer	Prehydrolysed single-phase silane
Monobond-S	Ivoclar Vivadent, Schaan, Leichtenstein	Silane primer	Ethanol, [3-(methacryloyloxy) propyl] trimethoxysilane
Calibra silane primer	Dentsply, USA	Silane primer	γ-Methacryloxypropyltrimethoxysilane, ethanol, acetone
DeTrey conditioner 36	Dentsply Sirona, USA	36% orthophosphoric acid	Phosphoric acid, highly dispersed silicon dioxide, detergent, pigment, water
Porcelain etchant	Angelus, Brazil	Porcelain conditioning agent	10% hydroflouric acid
DPI-RR cold cure	DPI, Mumbai, India	Cold cure self-polymerizing acrylic resin	Powder: Polymer: Polymethylmethacrylate beads Initiator: Peroxide such as benzoyl peroxide pigments: Salts of cadmium or iron or organic dyes Liquid: Monomer. Methyl methacrylate cross-linking agent: Ethylene glycol dimethacrylate inhibitor: Hydroquinone Activator: N′N dimethyl P-toluidine
Instron 4204	Canton, Massachusetts, USA	Universal testing machine	-

UDMA=Urethane dimethacrylate; TEGDMA=Triethylene glycol dimethacrylate; HEMA=Hydroxyethyl methacrylate; bisGMA=Bisphenol-A-diglycidylether dimethacrylate; PENTA=Dipentaerythritol penta acrylate monophosphate

RESULTS

Individual values obtained are tabulated in Table 2, and the mean values of all the groups obtained are depicted in Figure 2. The mean SBSs of Groups A, B, and C were 17.4 ± 0.75 MPa, 18.4 ± 0.74 Mpa, and 18.8 ± 0.92 Mpa, respectively. The one-way ANOVA followed by *post hoc* Tukey test revealed that the SBS of Group A was significantly lower than Group B ($P = 0.0208$) and Group C ($P = 0.011$), respectively. However, Group B and Group C did not significantly differ from each other ($P = 0.47$).

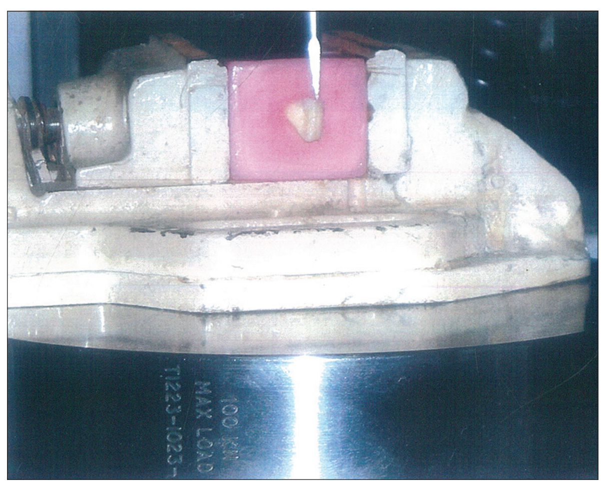

Figure 1: Specimen fitted on the Universal testing machine and shear load was applied perpendicular at the junction of the enamel surface and the porcelain veneer (bonded area)

DISCUSSION

The use of resin composite veneers has grown as an alternative to full crowns for anterior teeth, but this treatment was not durable due to its inherent drawbacks such as susceptibility to wear, marginal fractures, and discoloration. Moreover, their lack of natural translucency led to a dull and lifeless appearance. In response to the search for more durable esthetics, LiDiSi veneers have been introduced.

Recently, Abdulrahman *et al.* reported that LiDiSi veneers had a cumulative survival probability of 98.6% after an observation of up to 5 years.[6] Owing to this reason, attempts have been made to develop a resin cement that

Table 2: Shear bond strength values of the three study groups

Specimen number (for each group)	Group A: RelyX	Group B: Calibra	Group C: Variolink II
1	16.58	18.32	17.17
2	17.1	17.56	18.3
3	16.3	17.24	18.09
4	16.62	18.86	17.36
5	18.16	19.36	19.16
6	17.28	18.79	18.57
7	17.42	18.95	18.21
8	18.25	20.16	19.07
9	17.55	19.38	18.78
10	18.48	19.72	19.37
Mean±SD (MPa)	17.4±0.75[a]	18.4±0.74[b]	18.8±0.92[b]

Different superscript letters denote statistically significant differences between each group ($P \leq 0.05$) according to the *post hoc* Tukey's test. SD=Standard deviation

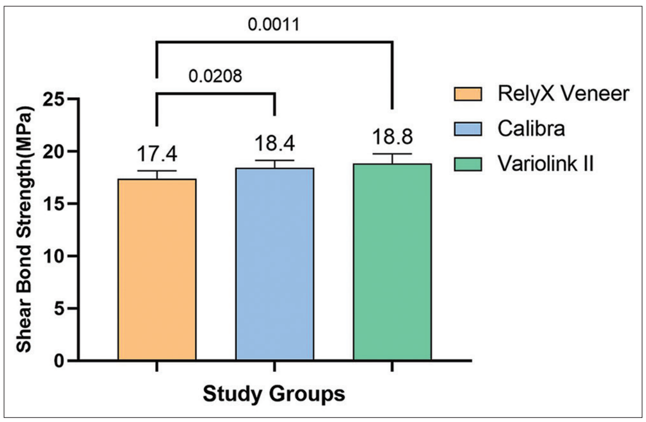

Figure 2: Bar Graph showing the mean shear bond strength of the three resin cement groups and the significant comparisons between them

will warrant a strong and durable bond between the tooth and the veneer.

The present study assessed the SBS of three resin cement to indicate clinical implications as shear stresses are more representative of the clinical situations. The current study compared one light-cure and two dual-cure resin cement.

Overall, Variolink II exhibited the greatest SBS among the experimental groups, while it was significantly lower for the RelyX group. This led to the rejection of the null hypothesis, which stated that SBS did not differ according to the type of the resin cement. The results corroborated with the findings of Kılıçarslan *et al.*, who, in their study, reported that dual-cure resin cement were stronger under shear stresses.[7] Light-cure resin cement, when used for cementation of all-ceramic restorations, have advantages such as adequate work time, but the degree of conversion varies according to the amount of light that reaches the resin.[8-12] Based on this information, it is recommended to avoid using light-cured cement for porcelain veneer bonding. The results of the present study also concorded with that of Elmarakby *et al.*[13] who found the worst exhibition of SBS by the RelyX resin cement system and with the study of Kumbuloglu *et al.*,[14] where Variolink II exhibited the highest SBS after thermocycling. However, Stewart *et al.* reported that light-cure showed higher SBS than dual-cure resin cement. The difference in results may be because, in the present study, the veneers were bonded to enamel purely, whereas, in that study, the veneer samples were bonded to the dentinal surface besides pretreating the surfaces.[15] The results were also dissimilar to that of Lee *et al.*, who reported a higher bond strength of the RelyX system than Variolink II.[16] The plausible reason for the incongruent finding may be the employment of shorter storage in distilled water (2 h) in that study in comparison to the current study (24 h).

Although the present study was carried out under optimum conditions pertaining to storage, manipulation, and cementation, the authors cannot disregard the inherent study limitation of an *in vitro* design. Therefore, all the clinical conditions could not be replicated, such as pulpal pressure, pH cycling, and cyclic loading, to simulate the homeostatic conditions of the oral cavity.

CONCLUSIONS

Within the limitations and parameters of the present study, it can be thus concluded that dual-cure resin cement are more favorable and ensure a stronger bond to teeth prepared to receive LiDiSi veneers than the light-cure counterparts. It is also noteworthy that the results of the present study are encouraging but cannot be taken as conclusive, and further studies are required utilizing more aggressive test conditions over a prolonged period to evaluate the long-term durability of the resin cement based on the nature of polymerization.

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Conflicts of interest
There are no conflicts of interest.

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