# Bonding of Resin Core Materials to Lithium Disilicate Ceramics: The Effect of Resin Cement Film Thickness

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The aim of this study was to investigate the effect of different resin cement film thicknesses on the shear bond strength of resin core materials to lithium disilicate ceramics. Forty IPS Empress 2 ceramic disks were bonded to the core materials (Bis-core and Smile) with resin cement film thicknesses of 50 or 100 µm. Shear bond strength was measured using a universal testing machine. Data were analyzed using two-way analysis of variance and independent *t* tests. The core material used and resin cement film thickness had a significant effect on shear bond strength values ($P < .001$). Greater resin cement film thickness resulted in decreased bond strength of the core materials to lithium disilicate ceramics. *Int J Prosthodont 2010;23:469–471.*

The bond strength between ceramic and core is an important aspect in the selection of a core buildup material. Although composites designed specifically for core buildups are available, composite resins have also been employed for the same purpose in recent studies.[1] Regarding the luting procedure, resin cements are the first choice to provide an efficient bond between tooth/core material and restoration, increase the resistance to fracture, and reinforce the remaining tooth structure. The composition of resin cements and their polymerization forms may influence their properties. In addition, these materials must also maintain a minimal film thickness over a long enough interval so that restorations can be seated completely.[2]

To the authors' knowledge, there are no studies in the literature as of yet that evaluate the effect of cement thickness on the bond strength of different core materials to ceramics. Therefore, the aim of this in vitro study was to investigate the effect of different resin cement film thicknesses on the shear bond strengths of resin core materials to lithium disilicate ceramic.

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## Materials and Methods

A total of 40 lithium disilicate ceramic disks (5-mm diameter, 2 mm high; IPS Empress 2, Ivoclar Vivadent) were fabricated. Following hydrofluoric acid etching (Pulpdent, Pulpdent Corp) for 2 minutes, disks were silanized for 30 seconds (ESPE Sil, 3M ESPE). To create a uniform resin cement thickness (Bifix QM, Voco), the ceramic disks were bonded to the core materials (resin core material [Bis-core, Bisco] and composite resin [Smile, Pentron]) using polyethylene molds (50 or 100 µm thick; Table 1). After polymerization (Optilux 501, Kerr), specimens were stored in distilled water for 24 hours at 37°C. The shear bond strength of each sample was measured using a universal testing machine (Lloyd LRX, Lloyd Instruments) at a crosshead speed of 0.5 mm/min.

Failure modes were observed with an optical microscope (Stereomicroscope, Wild M3B). Two specimens from each group were evaluated using scanning electron microscopy (SEM, Carl Zeiss). Data were analyzed using two-way analysis of variance (ANOVA) and independent *t* tests at a significance level of $P = .05$ (SPSS software, SPSS).

**Table 1** Test Materials and Their Composition According to Manufacturer

| Trade name | Type | Chemical composition* | Lot number | Manufacturer |
|---|---|---|---|---|
| IPS Empress 2 | Lithium disilicate ceramic | $SiO$: 57.0–80.0%, $Al_2O_3$: 0.0–5.0% $La_2O_3$: 0.1–6.0% $MgO$: 0.0–5.0%, $ZnO$: 0.0–8.0%, $K_2O$: 0.0–13.0%, $Li_2O$: 11.0–19.0%, $P_2O_5$: 0.0–11.0% Pigments: 8.0% | H14142 Shade 100 | Ivoclar Vivadent |
| Pulpdent porcelain etch gel | Hydrofluoric acid gel | 9.6% hydrofluoric acid gel | 020201 | Pulpdent |
| 3M ESPE Sil | Silane coupling agent | 3-MPS in ethanol | 4WB | 3M ESPE |
| Bis-core | Resin core material | Base: bis-GMA, glass filler, UDMA, fused silica (78 wt%) Catalyst: bis-GMA, TEGDMA, benzoyl peroxide | Base: 0500004033 Catalyst: 0500004653 | Bisco |
| Smile | Composite resin | PCbis-GMA, bis-GMA, UDMA, HDDMA, silane-treated barium boro-alumino silicate class, silane-treated nanoparticulated silica, zirconium silicate, photoinitiator, accelerator, stabilizer, silane, and pigments | 144063 | Pentron Clinical Technologies |
| Bifix QM | Dual-polymerizing luting composite | Bis-GMA, benzoylperoxide, amines, barium-aluminium-boro-silicate glass | 591115 | Voco |

MPS = methacryloxypropyltrimethoxysilane; bis-GMA = bisphenol A-diglycidyl methacrylate; UDMA = urethane dimethacrylate;
TEGDMA = triethylene glycol dimethacrylate; PCbis-GMA = polycarbonate modified–bis-GMA; HDDMA = hexanediol dimethacrylate.
*Provided by the manufacturers.

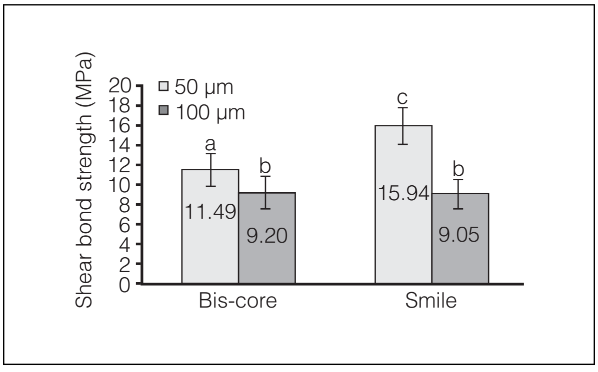


**Fig 1** Shear bond strength values of core materials to ceramics. Means with different letters are statistically significantly different ($P < .05$).

## Results

The mean shear bond strength values and standard deviations are presented in Fig 1. Two-way ANOVA revealed that both type of core material and the thickness of the resin cement had a significant effect on bond strength values ($P < .001$). Furthermore, significant interactions were observed between the type of core material and resin cement thickness ($P < .001$). The mean shear bond strength values of the core materials with a 50-µm-thick resin cement layer were statistically higher than the values with a 100-µm-thick resin cement layer ($P < .001$). With resin cement thicknesses of 50 µm, the mean shear bond strength value of the Smile composite resin group was statistically higher than the Bis-core resin core group ($P < .001$). However, there were no statistically significant differences between the core materials when a resin cement thickness of 100 µm was used ($P = .829$).

While the failures were mostly adhesive between the resin cement and ceramic when the resin cement was 50 µm thick, the failures were mostly cohesive within the resin cement when the resin cement was 100 µm thick (Fig 2, Table 2).

## Discussion

Amid the diverse spectrum of bond strength testing methods, the shear bond testing used in the present study was performed to measure the bond strength between a resin core and IPS Empress 2 ceramic surfaces. Additionally, the early bonding ability of a resin core to

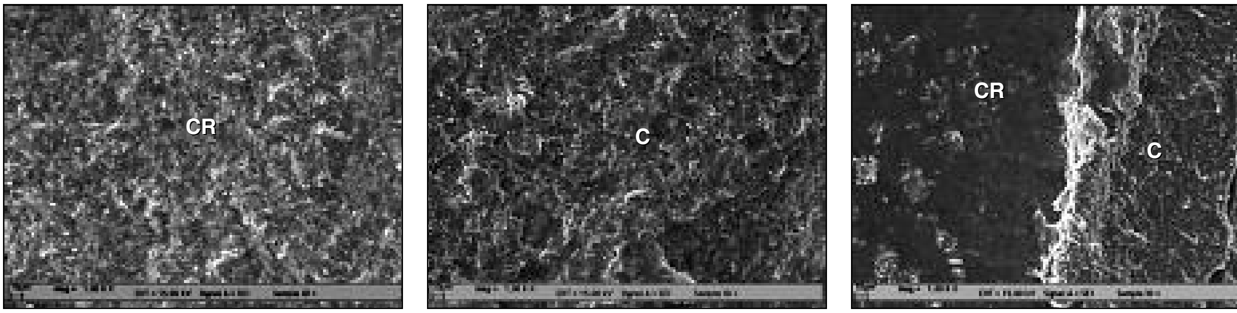


**Fig 2** Scanning electron microscopy photographs showing representative failure modes for each corresponding failure type: **(left)** adhesive between the cement and ceramic, **(center)** cohesive within the cement, and **(right)** mixed. CR = ceramic; C = cement (magnification ×1,000).

glass ceramic was investigated because unfavorable clinical situations such as debonding and fractures of ceramic restorations usually occur during or soon after the setting process.[3]

In the past, composite resin cements have demonstrated a greater film thickness than other cements, which is reflected in current International Organization for Standardization standards that require a film thickness at the time of seating of no greater than 50 µm for resin-based cements.[2] Furthermore, crown retention has been measured as a function of cement thickness, showing a decrease in retention with increasing cement film thickness.[4] A previous study by Molin et al[5] investigated the effect of film thickness on bond strength of a ceramic–composite resin joint and found no significant differences between cement thicknesses of 50 and 100 µm. However, the findings of the present study indicated higher bond strength values with a cement thickness of 50 µm. The differences in the testing methods for bond strength could be one of the causes of such a discrepancy in the results.

The fracture modes were predominantly adhesive between the resin cement and ceramic in groups with a cement thickness of 50 µm. However, in the groups with a resin cement thickness of 100 µm, failures were mostly cohesive in the resin cement (Table 2). This could be related to a reduced degree of conversion, and eventually, incomplete polymerization of a thicker resin cement layer.

The present study showed a significant difference in bond strength between Smile and Bis-core resin cements with a cement thickness of 50 µm. This could be related to the differences in filler load, filler type, resin matrix, and formulation. On this account, it is noteworthy that the filler-resin ratio is important since the penetration of light into the composite is more difficult when the filler proportion is higher. With that in mind, Smile, with a lower filler load (75%), might have shown a higher degree of conversion, and thereby a higher bond strength than Bis-core with a filler load of 78% by mass. However, no differences were observed with the cement thickness of 100 µm, and the bond strength values were lower than those observed with a cement thickness of 50 µm. This could be a result of an incomplete polymerization of both Smile and Bis-core when thicker resin cement was used between the ceramic and core materials.

**Table 2** Fracture Mode Analysis of the Specimens

| Resin core material/ resin cement thickness | Adhesive between cement and ceramic | Cohesive within cement | Mixed |
|---|---|---|---|
| Bis-core | | | |
| 50 µm | 6 | 2 | 2 |
| 100 µm | 3 | 4 | 3 |
| Smile | | | |
| 50 µm | 5 | 2 | 3 |
| 100 µm | 3 | 4 | 3 |

## Conclusion

Increasing resin cement thickness could have a decreasing effect on the bond strength of resin core materials to ceramics. Additionally, Smile composite resin could be used as a core material under lithium disilicate ceramic as an alternative to Bis-core resin core material.

## References

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