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Effect of Aging on the Bond Strength between Lithium Disilicate and Preheated Composite

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ABSTRACT

Objective: investigation of the microshear bond strength (µSBS) between lithium disilicate with preheated packable composite, flowable composite and resin cement by comparison of their (µSBS) before and after aging.
Material and method: Ninety samples were prepared and divided into three groups; preheated packable composite, flowable composite and resin cement. Materials were injected into plastic transparent molds (2x2mm) on the surface of lithium disilicate discs pretreated previously with hydrofluoric acid 4.5% and silane coupling agent. Then each group was divided into 2 subgroups (15 samples each). The first subgroup didn't receive any aging procedure while the second subgroup was thermocycled (5000 cycles) to simulate aging process. µSBS test was performed for each sample by universal testing machine.
Results: before aging the highest µSBS was recorded for preheated packable composite, while after aging there was no significant difference between all tested materials.
Conclusions: the preheated packable composite is a reliable substitute of flowable composite and resin cement in cementation of lithium disilicate ceramic restorations.

Keywords: Lithium disilicate; Preheated composite; Thermocycling; µ-shear bond strength.

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INTRODUCTION

Lithium disilicate combines excellent esthetics, high translucency, biocompatibility, low plaque accumulation, wear resistance, color stability, durability and good mechanical properties (Ariaans *et al.*, 2016; Kwon *et al.*, 2018; Tysowsky, 2009) Adhesive cementation of lithium disilicate increases its strength and fracture resistance and can be used with minimal preparations (Chen *et al.*, 1998). Routinely, lithium disilicate is cemented with resin cement but it is weak due to lack of fillers (Scherer *et al.*, 2018). The recent advance in cementing lithium disilicate restorations is using a preheated packable composite as a cementing material (Goulart *et al.*, 2018). Packable composite is a reliable restorative material due to its good wear resistance, excellent esthetics as well as its large amount of fillers content that decreases its polymerization shrinkage and increases its mechanical properties (Acquaviva *et al.*, 2009; Elkaffas *et al.*, 2019; García *et al.*, 2006; Roeters *et al.*, 2005). The disadvantage of using packable composite as a cementing material is its high viscosity and low adaptation. Preheating of packable composite was found to decrease its viscosity and increase its adaptation and also decrease its film thickness (Blalock *et al.*, 2006; Fróes-Salgado *et al.*, 2010). The hypothesis of this research was that the microshear bond strength (µSBS) of the preheated packable composite is similar to that of flowable composite and resin cement. Additionally, aging has no effect on µSBS of any of them.

MATERIAL AND METHOD

Materials

Lithium disilicate CADCAM blocks (IPS e.max CAD HT, Ivoclar Vivadent, Schaan, Liechtenstein), packable composite (Filtek Z350, 3M ESPE, Minnesota, USA), flowable composite resin (Filtek Z350 XT, 3M ESPE, Minnesota, USA), light cure resin cement (RelyX Veneer, 3M ESPE, Minnesota, USA), hydrofluoric acid 4.5% as (ceramic etchant) (IPS Ceramic Etching Gel, Ivoclar Vivadent, Schaan, Liechtenstein) and silane coupling agent (ceramic primer) (Monobond Plus, Ivoclar Vivadent, Schaan, Liechtenstein) were used in the current study.

Methods

Ninety samples were prepared and divided into three groups (30 samples each); preheated packable composite group, flowable composite group and resin cement group. Then each group was divided into 2 subgroups (15 samples each). The first subgroup did not receive any aging procedure while the second subgroup was thermocycled.

Sample preparation:

Lithium disilicate CADCAM blocks were cut into 2 mm thickness discs using a special saw (isomet 1000, Buehler, Virginia, USA). Discs were divided in groups as mentioned above. Lithium disilicate samples underwent crystallization using a special furnace (Programat CS/CS2, Ivoclar Vivadent, Schaan, Liechtenstein). Each lithium disilicate disc was surface treated according to the manufacturer instructions. First, discs were etched with hydrofluoric acid gel for 20 seconds and thoroughly rinsed with water spray and dried with oil free air till chalky white appearance reveals. Then, silane coupling agent was applied to the etched ceramic surface for one minute and then dispersed with air (manufacturer's instructions). Packable Composite was preheated using a composite heater (ENA Heat, Micerium S.P.A., Avegno (GE), Italy). Preheated packable composite, flowable composite and resin cement were injected into custom made transparent plastic molds (2 mm height, 2 mm diameter) on the previously treated lithium disilicate disc. Then, each sample was light cured using LED curing light (LED Elipar, 3M ESPE, Minnesota, USA).

The three aging subgroups were placed in a thermocycling device (Robota automated thermal cycle, BILGE, Turkey) for 5000 cycles. Dwell times were 25 seconds with a lag time 10 seconds. The low temperature point was 5 °C and the high temperature point was 55 °C (Morresi *et al.*, 2014).

Bond strength evaluation:

Microshear bond strength test (µSBS) was performed for each sample. Each disc with its own attached microcylinder was installed into a specially designed centralized hole with a sample holder which was tightened horizontally with screws to the lower fixed compartment of a universal testing machine (Model 3345; Instron Industrial Products, Norwood, MA, USA) has a loadcell of 5000 N. Data was recorded using computer software (Instron® Bluehill Lite Software Instron Industrial Products, Norwood, MA, USA). A loop prepared from an orthodontic wire (0.14 mm diameter) was wrapped around the bonded microcylinder assembly as close as possible to the base of the microcylinder and aligned with the loading axis of the upper movable compartment of the universal testing machine. A shearing load with tensile mode of force was applied via universal testing machine at a crosshead speed of 0.5 mm/min. The load required to debonding was recorded in Newton. The load at failure was divided by the bonding area to express the bond strength in MPa:

$\tau = P/\ \pi r^2$

where, τ = microshear bond strength (in MPa), P = load at failure (in N), π =3.14 and r = radius of microcylinder (in mm).

Statistical analysis

Data analysis was performed in several steps. Initially, descriptive statistics for each group results. Two-way ANOVA followed by pair-wise Tukey's post-hoc tests were performed to detect significant effect of variables (material and aging). One-way ANOVA and student t-test was done between groups and subgroups. Sample size (n=15) was large enough to detect large effect sizes for main effects and pair-wise comparisons, with the satisfactory level of power set at 80% and a 95% confidence level. Statistical analysis was performed using GraphPad InStat statistics software for Windows (GraphPad Software Inc., California, USA). P values ≤0.05 are statistically significant in all tests.

RESULTS

Regarding the non-aged groups, it was found that the highest µSBS was recorded for preheated packable composite group and the lowest µSBS was recorded with both flowable composite and resin cement group (table 1). Regarding the aged groups, there was non-significant difference between the different used materials. (table 1). Irrespective of aging, there was non-significant difference in µSBS between different used materials (table 2). Regardless of type of material, it was found that µSBS significantly decreased with aging (table 3).

DISCUSSION

Regarding the non-aged groups, it was found that the highest µSBS was recorded for preheated packable composite group and the lowest µSBS was recorded with both flowable composite and resin cement group (table 1). Regarding the aged groups, there was non-significant difference between the different used materials. (table 1). Irrespective of aging, there was non-significant difference in µSBS between different used materials (table 2). Regardless of type of material, it was found that µSBS significantly decreased with aging (table 3).

CONCLUSION

The preheated packable composite is a reliable substitute of flowable composite and resin cement in cementation of lithium disilicate ceramic restorations.

Table 1: Comparison of microshear bond strength test results (Mean±SD) as function of material groups before and after thermal aging.

Variables		Thermally		Statistics
		Non-aged	Aged	P value
Material group	Composite group	26.187^{Aa}±8.13	15.829^{Ab}±3.91	0.0001*
	Resin cement group	19.651^{Ba}±5.91	17.846^{Aa}±5.16	0.3807ns
	Flowable group	21.209^{Ba}±4.11	15.769^{Aa}±3.46	0.0005*
Statistics	P value	0.0177*	0.3215 ns	

Different superscript capital letter in the same column indicating statistically significant difference (p < 0.05). Different superscript small letter in the same row indicating statistically significant difference (p < 0.05) *; significant (p < 0.05) ns; non-significant (p>0.05).

Table 2: Comparison of total microshear bond strength test results (Mean±SD) as function of material groups.

Variables		Mean±SD
Material group	Composite group	21.009^{A}±6.02
	resin cement group	18.748^{A}±5.54
	Flowable group	18.489^{A}±3.78
Statistics	P value	0.1251 ns

Different superscript capital letter in the same column indicating statistically significant difference (p < 0.05)*; significant (p < 0.05) ns; non-significant (p>0.05).

Table 3: Comparison of total microshear bond strength results (Mean±SD) as function of thermal aging.

Variables		Mean± SD
Thermal aging	Non-aged	**$22.349^{A}\pm6.05$**
	Aged	**$16.481^{B}\pm4.18$**
Statistics	P value	**<0.0001***

Different superscript capital letter in the same column indicating statistically significant difference ($p < 0.05$)*; significant ($p < 0.05$) ns; non-significant ($p>0.05$).

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