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Assessment of two repairing techniques for a novel lithium disilicate-based ceramic

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Abstract

Background This research was done to evaluate the bond strength using two repair methods with lithium disilicate ceramic.

Methods Cojet and clearfil repair methods were used to repair lithium disilicate ceramic. The ceramic was sliced into slices before sintering (30 samples). Vita Ambria (Vita, Zahnfabrik, Germany) ceramic was used, surface-treated with the 2 repair systems and then bonded to composite. Samples are stored, thermocycling was done, and then, shear loading was done until fracture. Bond strength values were collected and statistically analysed.

Results The results showed that the cojet surface treatment showed significantly more bond strength (14.43 ± 1.46 Mpa) than the clearfil surface treatment showing (4.16 ± 1.33) as indicated by paired *t*-test $p \leq 0.05$.

Conclusions Bond strength between composite and the ceramic Vita Ambria is better using cojet surface treatment than using the clearfil system.

Keywords Repair, Lithium disilicate, Composite

Background

Ceramics are used nowadays on a very large scale worldwide as it has superior aesthetic quality, but this should be accompanied by proper longevity and serving time. Lithium disilicate ceramics are considered relatively with low fracture toughness and that is why it is subjected to fracture due to crack propagation, especially the veneering layer (Garbelotto et al. 2019). There are many causes for the chipping of the veneering part or piece of it, as improper design of the infrastructure, problem in the matching of coefficient of thermal expansion, improper preparation, improper laboratory steps, presence of porosities, improper occlusion, excessive force by trauma or habits as bruxism (Maawadh et al. 2020). The chipping need to be well assessed and to reach a decision whether

do we have to replace it or it can be repaired (Zarone et al. 2019).

Heintze and Rousson in 2010 described three chipping degrees with different clinical response: grade 1 (small, to be just polished), grade 2 (moderate, to be repaired with composite) and grade 3 (severe, the prosthesis must be replaced) (Heintze and Rousson 2010). From the most common sites that are considered an indication for repair, the incisal edges are prone to chipping due to improper occlusion sometimes (Nogueira et al. 2023). In most cases, repair should be done to prevent aesthetic and functional complaining of the patient (Stefanie et al. 2023).

The ceramic repair is considered an easy, cheap approach with saved chairside time and patient's time. Before taking the decision to repair, the restoration should have good margins and aesthetics (Reston et al. 2008). In addition, how large is the chipping and its site is an important factor to determine the success of the repair and the ability to be done clinically (Soares 2023).

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Repair could be done directly intraorally or indirectly in the laboratory.

To have a successful repair for a reasonable time, there should be proper bonding between the ceramic and the composite (Özcan 2014). Many methods are introduced to repair the ceramic with good bond with the composite. The ceramic surface should be treated using sandblasting with alumina particles (accompanied by silica coating or not), and surfaces of glass ceramics as lithium disilicates should be etched with 10% hydrofluoric acid for 1 min (Özcan and Volpato 2015). Then adhesion promoters as silane and composite resin should be applied.

This study was done to assess the bond strength between the composite and lithium disilicate ceramic after surface treatment with two methods, the cojet and the clearfil systems. The null hypothesis is that the cojet system will aid in more bond strength with the composite resin used for repair.

Methods

Thirty lithium disilicate samples were used. Vita Ambria was divided into 2 groups, 1 and 2, according to the surface treatment systems.

Group 1: Vita Ambria repair using cojet repair system (3 M ESPE, Seefeld, Germany) $n = 15$.

Group 2: Vita Ambria repair using clearfil repair system (Kuraray Medical INC 1621 Sakazu, Kurashiki, Japan) $n = 15$.

Blocks of Vita Ambria were sliced into slices of 2 mm thickness. They were cut by 0.5 mm disc (Buehler USA) attached to Isomet 4000 low-speed precision sectioning saw at velocity 2500 rpm under continuous water irrigation, and finishing was done using silicon carbide papers 300 grits, which were cleaned for 3 min in ultrasonic cleaner with distilled water.

The Vita Ambria slices were fired in compatible ceramic furnace (VITA Vacumat) according to manufacturer's instructions. Holding time of crystallization was 10 min at temperature 830 °C. Slices were removed from the furnace and grouped into two groups according to the repair system.

Slices were put in acrylic blocks leaving one surface uncovered, for proper handling during shear bond strength assessment.

Surface treatment was done with each repair kit according to the manufacturer's instructions. A special mould was manufactured to standardize the dimensions of the composite samples that will be bonded to the ceramic slices. The mould has inner hole with diameter 5 mm and height of 2 mm with outer stabilizing ring.

The air pressure of the microetcher was set to 30–45 psi, so the energy of impact is enough for proper coating. Cojet sand was used with the etcher (30 μ aluminium

oxide particles covered with silicone oxide). Blasting was done from distance 7–10 mm perpendicular to the slices. Even coating was done for 15 s. After coating, ESPE silane was painted using clean brush and left to dry for 5 min. Visio bond was applied to the silanized surface of the slices with a brush and light-cured for 20 s. Z 100 light-cured composite resin was applied to the ceramic using the tailored Teflon mould and cured with light 500 mW/cm² intensity and 5 mm away from the slices.

For the other group, particle abrasion was done for 20 s by 50 μ alumina with 2.5 bars pressure from a distance of 10 mm. Slices were rinsed and then dried with oil-free air using a compressor. Etching with phosphoric acid was done to the surface, left for 20 s, then washed and dried. Clearfil SE bond primer containing phosphate monomer and clearfil porcelain bond activator (silane) was applied to the surface and left for 5 s. The volatile constituents were evaporated using air stream. Proper dryness of the surface was done. Clearfil SE bond containing phosphate monomer was applied. Methacrylate monomer, hydroxyethyl methacrylate and inorganic fillers were applied to the surface with a brush, uniformed with light air stream and light-cured for 10 s. Clearfil AP-X light-cured composite was used; it contains silanated barium glass, colloidal silica, silica, BISGMA, TEGDMA and dicamphorquinone. Composite was put using the mould and light-cured for 40 s, 500mW/cm² from 5 mm distance. The slices were stored for 7 days in distilled water and then thermocycled between 5 and 55 °C for 7500 cycles with a 30 s dwell time.

Shear test was done to assess the bond strength, using computer-controlled material testing machine with load cell of 5 KN, and then, data were recorded. Shear test was done by compressive mode of load applied at the ceramic composite bond using mono bevelled chisel shaped metallic rod at crosshead speed of 0.5 mm/minute. Load needed for breaking the bond was recorded in Newton. Load was divided by the bonded area to show bond strength $T = p/\pi r^2$, T = shear bond strength, Mpa), p = load at failure (N), $\pi = 3.14$, and r = radius of disc (mm).

Results

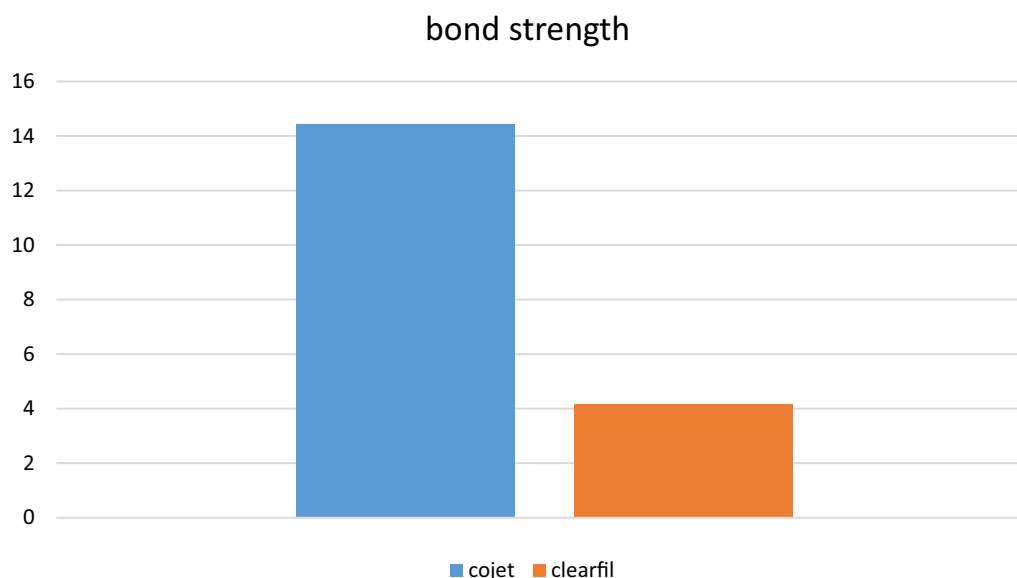
GraphPad InStat (GraphPad, Inc.) software is used. Significance value was $p \leq 0.05$. Variance was checked if it is homogenous. Errors as well as normal distribution were also checked.

Descriptive analysis for shear bond strength (Mpa) was carried out to find the mean, standard deviation (SD), minimum, maximum and 95% confidence interval of the 2 surface treatments tested (Table 1 and Fig. 1).

Surface treatment with cojet method showed significantly higher bond strength with composite 14.43 Mpa

Table 1 Analysis of the shear bond with the two surface treatment methods

Variables	Mean \pm standard deviation	Minimum	Maximum	95% confidence level (low)	95% confidence level (high)	P value
Cojet	14.43 \pm 1.46	10.78	16.34	13.33	15.53	0.0001
Clearfil	4.16 \pm 1.33	2.81	7.82	3.05	5.27	0.0001

Significance ≤ 0.05 **Fig. 1** Shear bond strength of the two surface treatment methods

than when using clearfil 4.16 Mpa as indicated by paired t test ($p = 0.0001$).

Discussion

Repair of lithium disilicate ceramics is a very important point to study. This type of ceramics is still considered weak and liable to chipping although it gives the best aesthetic results. Therefore, repair method is an important point of concern to dentists. In vitro studies mainly give a clue to the clinical performance. Lithium disilicate (Amber Mill) shows after etching loose structure of many small thin lithium disilicate crystals 0.2 μm in length, with patches of glassy matrix. The unsintered material shows cracks that are gone with crystallization giving strength of 450 Mpa.

Bonding to lithium disilicate ceramics depends on mechanical and chemical methods as it has a glassy content (Phark et al. 2016). Bonding is done with the surface after application of bonding resin. Hydrofluoric acid is used to remove the amorphous glass in glass ceramics only, so the irregular crystals are exposed, and then, the resin composite can penetrate and be locked after polymerization. Etching can precipitate silica fluoride salts on

the surface that can impair bonding, so ultrasonic cleaning is beneficial (Shimada et al. 2002). Silane bifunctional organic molecules are used after etching; it can bond with the resin of the composite and on the other side with the silica of the glass ceramics only (Phark and Duarte 2022).

Other surface treatments are used air abrasion with alumina particles with or without silica layer for promoting repair of fractured part of ceramic with composite (Garbelotto et al. 2019). Increasing the surface area increases the bonded surface area and the bond strength (Sato et al. 2016). This is one of the explanations approving the results of our study where the abrasion using the cojet method showed more bonding to the repair composite than the clearfil method. Opposing our results, other studies as done by Ataoll and Ergun in 2018 showed that the etching as with clearfil gives more uniform bonding than with blasting as done with the cojet and with more preferable bond (Seda et al. xxxx). (Figs. 2 and 3)

The cojet system has fine particle size for abrasion 30 μm , so the speed should be slow. During the process, heat is generated and particles are embedded deep 15 μm in the surface. Studies augmenting our findings as Barutcgil et al. in 2019 explained the better results with the cojet

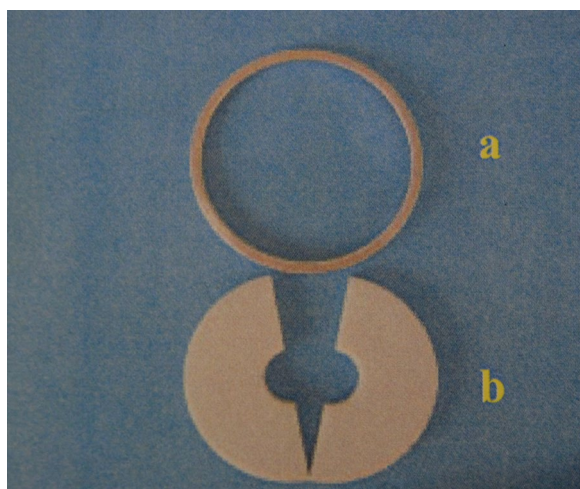


Fig. 2 Teflon mould with outer rings

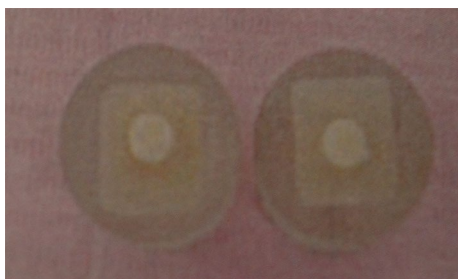


Fig. 3 Composite bonded to the slices

system in bonding the ceramic with the resin by the fact that the silica coated on the surface after abrasion with silica-coated alumina particles will react chemically with the silane applied after linking it with the resin of the repair composite (Barutcigil et al. 2019). Another study by Khan et al. in 2017 reviewed the researches adding to the prove that chemical coating with silica increased bond strength between the ceramic and composite chemically. Other studies showed equal results of bonding after using cojet and clearfil as that by Galal et al. in 2022, but this was with zirconia oxide-based ceramics (Galal et al. 2022). But opposing our results, Wang et al. in 2022 found that among many methods of repair, one of them is the cojet; the hydrofluoric acid etching followed by the universal adhesive showed the best bond strength results (Wang et al. 2022).

Also confirming our results, some studies as that by Schwenter et al. in 2016 who found that the hydrofluoric acid etching and silane application might be a cause to decrease bond strength due to some surface changes (Schwenter et al. 2016). In addition, Silva et al. in 2018 found that mechanical grinding and then

application of bonding resin give better bond than with the use of hydrofluoric acid etching (Silva et al. 2018). But as a fact, how durable is the repair depends on the surface created and how the dentist stick to the proper instructions of the repair procedure as found by Mesquita et al. in 2021 (Mesquita et al. 2021). Also this was concluded in a review by Alqarawi et al. in 2022 that it was all about the proper following of the dentist to the manufacturer's instructions in using the repair system chosen (Alqarawi and Alhumaidan 2022).

In our study, storage in water and thermocycling were used to simulate the intraoral environment somehow. In addition, it gives an effect from the early stages of ageing (Byeon et al. 2017). According to our study, the use of cojet system is preferred over the clearfil system for bonding of this type of lithium disilicate ceramic. From the limitations of this study, other types of ceramics with modifications in the filler content need to be studied. In addition, shear bond strength was the only tested forces here, which is not the situation intraorally. In addition, more clinical research needs to be done to approve our results.

Conclusions

Bond strength between composite and the ceramic Vita Ambria is better with cojet surface treatment than with the clearfil system. Clinical implication: Cojet system is recommended for repair process of restorations made from this new ceramic.

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Author contributions

RM carried out the practical work, collected the data and was a major contributor in writing the manuscript. GE performed the statistical analysis, made final revision and wrote the manuscript. MM carried out final writing and editing, plagiarism step and submission. YE carried out the laboratory work and performed grammar correction. All authors have read and approved the final manuscript before submission.

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Not applicable.

Consent for publication

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