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Evaluation of Marginal and Internal Fit in CAD/CAM-Fabricated Indirect Restorations

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ABSTRACT

Objectives: This study investigated the effect of marginal adaptation and internal fit of premolar teeth restored with indirect overlays, fabricated from different CAD/CAM materials (lithium-disilicate and composite blocks).

Materials and Methods: Twenty-two intact premolars with standardized concave chamfer overlay preparation were divided into two groups (n= 18) Group (A): lithium disilicate blocks and Group (B): composite blocks. All groups cemented with dual cured resin cement. After 24h of storage at 37°C followed by thermocycling. Marginal gap evaluation evaluated using a stereomicroscope at x50 magnification at 4 points at each surface. Specimens were then sectioned mesiodistally to assess internal fit. Statistical analysis was performed using student t-test at $p<0.05$.

Results: Composite blocks showed higher but statistically similar marginal and internal gap mean values.

Conclusions: Using composite blocks in fabrication of overlay restorations provided comparable marginal and internal gap results to lithium disilicate blocks.

Keywords: *RESIN COMPOSITE, LITHIUM DISILICATE, RESIN CEMENT, INDIRECT RESTORATIONS.*

1. INTRODUCTION

Dental clinicians often face difficulties in making restorative decisions daily, depending on the clinical situation and the extent of damage to the remaining tooth structure. There are several treatment options available for restoring teeth in the posterior region. Indirect partial restorations like inlays, onlays, and overlays strengthen teeth that have been compromised by caries or fractures and preserve the highest amount of healthy tooth structure. The dentist prefers indirect restorations for large cavities because they are less invasive than full coverage crowns, which require 40% less tooth removal.(1)

Tooth-colored materials are increasingly popular due to patient interest in aesthetic restorations. There are two main strategies for restoring dental cavities: the direct technique, using composite resin that bonds well with tooth structures and is polymerized in the mouth, and the indirect technique, involving CAD/CAM composite restorations fabricated externally. Indirect resins offer superior marginal integrity, wear resistance, reduced shrinkage, and increased fracture resistance.(2)

The new CAD/CAM technology for indirect restorations utilizes highly esthetic materials, including resin-reinforced composites and lithium disilicate blocks. This technology offers time savings, enhanced accuracy, and reduced sensitivity to technique compared to traditional direct restoration methods.(3)

Lithium disilicate blocks, made from glass ceramic material, are the most commonly used option for all-ceramic restorations, regarded as the gold standard. They offer a higher survival rate, an aesthetically pleasing appearance, reduced abrasion or wear on opposing teeth, and greater strength compared to traditional porcelain. (4). The advanced lithium disilicate glass ceramic, known as CEREC Tessera, demonstrated fewer microcracks during fabrication, less wear on opposing teeth, and increased durability. These enhancements resulted in better marginal adaptation. (5,6)

Resin composite CAD/CAM blocks have recently been introduced on the market, offering improved mechanical properties. Due to their higher filler content and degree of conversion when compared to direct composite materials. These blocks demonstrate adequate wear resistance and the ability to absorb functional stresses, thanks to their low modulus of elasticity. Additionally, the newly introduced Brilliant Crios blocks bring several advantages to the CAD/CAM field, including the absence of firing steps, ease of milling, and the capability of being repaired in the event of a fracture, while also showing acceptable marginal adaptation. (7–9)

The gold standard for any indirect restoration cementation is resin cement materials due to its superior physical properties for better retention and marginal adaptation of restorations compared to other traditional cement materials.(10)

Marginal and internal adaptation are the most critical factors for the success and longevity of indirect restorations. Caries and periodontal diseases can result from biofilm accumulation, which may occur if cement dissolves due to any marginal gaps or spaces between the tooth and the restoration.(11,12)

The study aimed to compare the marginal adaptation and internal fir of indirect overlay restorations between two CAD/CAM materials (advanced lithium disilicate and resin composite blocks). The null hypothesis proposed that there would be no significant difference in marginal adaptation and internal fit among both materials.

2. MATERIALS & METHODS

In this in-vitro study, twenty-two recently extracted sound premolar teeth were collected, ensuring that they were free from caries, hypoplastic defects, fractures, or cracks. Teeth dimensions were recorded using digital caliper for standardization. Teeth were stored in a saline solution containing 0.1% thymol at 4°C. The teeth were positioned crown-up, with their long axis vertical, and secured in chemically activated acrylic resin (Acrostone, Egypt) inside cylindrical molds. The acrylic resin extended to within 2 mm of the cementoenamel junction (CEJ). The specimens were randomly divided into two groups according to type of material as following: Group (A) lithium disilicate blocks (CEREC TESSERA) and Group (B) resin reinforced composite (BRILLIANT CRIOS). Brand name, product description, composition and manufacturer of the materials used are detailed in Table 1.

2.1. Sample size calculation:

Sample size calculation was performed using G*Power version 3.1.9.7. By adopting an alpha and a beta level of (0.05) i.e. power= 95% and an effect size of (1.64) calculated based on the results of Mohammed et al, (2020)(13).The predicted sample size (n) was a total of (22) samples.

2.1. Cavity preparation:

All specimens were prepared with concave chamfer finish line preparation for overlay restoration done using high-speed handpiece (NSK high-speed handpiece (NSK, Nakanishi Inc., Japan) with continuous water cooling. Preparation done under magnification 2.5x loupes (Univet, Italy). Occlusal reduction was 2 mm for functional cusps and 1.5 mm for non-functional cusps by using depth markers stones (Oekodent, Germany) size (1.5 mm and 2 mm) to standardize depth operating from its tip to end for the purpose of occlusal reduction, followed by using barrel-shaped trapezoid diamond bur (Oekodent, Germany) to connect the depth cuts and obtain occlusal reduction in an anatomical form. Chamfer finish line was done using tapered diamond stone with round end (Oekodent, Germany). Periodontal probe and silicone index were used as a guide to standardize all cavity dimensions.

2.2. Fabrication of restorations from CAD/CAM blocks:

The prepared teeth were then scanned using extraoral scanner 3Shape D700 (TS) (3Shape, Copenhagen, Denmark), then overlay restorations were designed using Exocad software (Exocad GmbH, Darmstadt, Germany), and milled by Cerec Primemill (Dentsply Sirona, USA) milling unit. Overlay restorations of group A were then subjected to crystallization/glaze firing at 760°C, while those of group B were finished and polished only. The restorations were examined for cracks under magnification with the use of dental loupes and light-curing equipment. All samples were polished according to the manufacturer's guidelines.

2.3. Adhesive application:

Pretreatment of all prepared teeth was done by applying a 37% phosphoric acid etching gel (Fine Etch 37) for 15 seconds, followed by rinsing with water for 15 seconds. After air-drying, one layer of the universal adhesive (Prime & Bond, Dentsply) was applied using a sponge micro brush, rubbing for 20 seconds, and then light-cured for 20 seconds with an LED light-curing (SDI radii plus, SDI, Australia). The surface treatment for both restorations was done according to manufacturers' guidelines as follows: for group (A) lithium disilicate blocks (CEREC TESSERA), applying hydrofluoric acid 9% (Ultradent, USA) for 20 seconds to etch the internal surface of the restoration, then rinsing the surface for 20 seconds and air drying. Silane coupling agent (Ultradent, USA) was used for 60 seconds and air-dried. While for group (B) composite blocks (BRILLIANT CRIOS), sandblasting was done by 29 µm aluminum oxide particles at 0.2 MPa air pressure using an Aquacare single dental air abrasion unit (London, UK) for 20 seconds and 10 mm distance. Then the ultrasonic cleaner was used for 5 minutes to clean the restorations of any powder, and finally all restorations were gently air-dried. For both types of restorations, a thin layer of Prime & Bond universal adhesive (Dentsply Sirona, Germany) was actively applied for 20 seconds, air-thinned for 10 seconds, and then cured for 20 seconds using the LED polymerization unit. Both groups were cemented using dual-cure adhesive resin cement (Calibra Ceram, Dentsply, Germany) with gentle finger pressure. After excess cement was removed with a micro-brush, light curing from all surfaces was done for 20 seconds for each surface. Finally, all specimens were finished and polished according to the manufacturer's instructions for both restorations. The specimens were then stored in distilled water at 37°C for 24 hours. All specimens were thermally cycled in distilled water for 3,000 cycles at 5±2°C/55±2°C, time using a thermocycling device (SD Mechatronik Thermocycling, Julaba, Germany).

Table (1): Brand Name, Product Description, Composition and Manufacturer of the used materials.

Brand Name	Product Description	Composition	Manufacturer
Brilliant Crios	Nano hybrid Resin Composite Block	Dental glass Barium glass Size < 1.0 µm, Amorphous silica SiO2 Size < 20 nm, Resin matrix Cross- linked methacrylates and Inorganic pigments such as ferrous oxide or titanium dioxide	Coltene, Germany
Cerec Tessera	Advanced Lithium disilicate block	Lithium disilicate (Li2Si2O2), Virgilite(Li0.5AL0.5Si2.5O6), new virgilite crystals are formed on a nano-growth scale 0.5um in length	Dentsply Sirona, Germany
Prime & Bond Universal Adhesive	Universal adhesive	Urethanedimethacrylate 2- hydroxyethyl methacrylatePhotoinitiatorsEthanol, Ethyl alcohol Water	Dentsply Sirona, Germany
Calibra Ceram	Dual cure resin cement	Dimethacrylate Resins; Camphorquinone (CQ) Photoinitiator; Stabilizers; Glass Fillers; Fumed silica; Titanium Dioxide; Pigments	Dentsply Sirona, Germany

2.4. Marginal adaptation evaluation:

Marginal gap measurements for all specimens were done using stereomicroscope (Leica MZ16FA, Leica, Wetzlar, Germany) at x40 magnification at 4 points at each surface (buccal, lingual, mesial and distal) of the tooth with the aid of image analysis software (ImageJ, USA). For each specimen, the average of all measured points was calculated.

2.5. Internal fit evaluation:

Specimens were rinsed thoroughly after measuring the marginal adaptation and mounted horizontally on an acrylic block. The specimens were sectioned longitudinally through the restoration's center in a mesiodistal direction with a diamond saw of the hard tissue microtome under water coolant. The internal adaptation measured at 5 points; mesial, distal and 3 points at occlusal, at x50 magnification under the stereomicroscope (Leica MZ16FA, Leica, Wetzlar, Germany). Leakage values were determined in millimeters along the interface.

2.6. Statistical analysis:

Statistical analysis was performed with R statistical analysis software version 4.3.1 for Windows. The significance level was set at $p<0.05$. Numerical data were reported as mean and standard deviation (SD) values and evaluated for normality via Shapiro-Wilk's test and variance homogeneity using Levene's test. Intergroup comparisons were conducted using independent student t-test.

3. RESULTS

2.1. Marginal adaptation:

Composite group (90.85±16.34μm) had a higher marginal gap mean values than Lithium disilicate group (88.10±15.60 μm), yet the difference was not statistically significant (p=0.355). (Table 2)

Table (2): Comparisons of marginal adaptation (μm) of both materials.

Marginal gap (μm) (Mean±SD)		p-value
Lithium disilicate (A)	**Composite (B)**	
88.10±15.60	90.85±16.34	**0.355ns**

P=0.05, ns: not significant at P>0.05

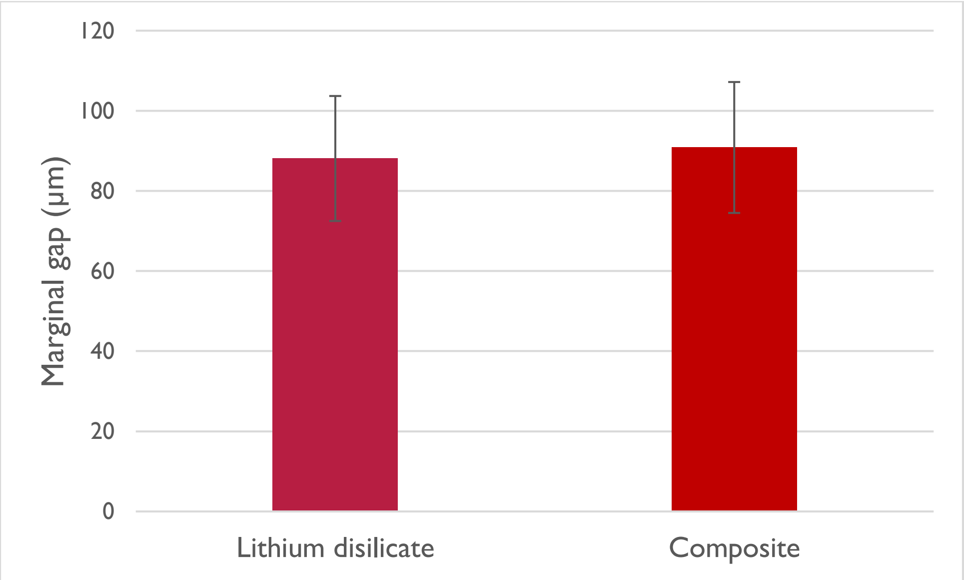

Figure 1: Bar chart showing marginal gap mean values (μm) for both groups.

2.2. Internal fit:

Composite group (98.12±16.38 μm) had a higher internal gap mean values than Lithium disilicate group (95.54±17.25 μm), yet the difference was not statistically significant (p=0.243). (Table 3)

Table (3): Comparisons of internal fit (μm) of both materials.

Internal fit (μm) (Mean±SD)		p-value
Lithium disilicate (A1)	**Composite (A2)**	
95.54±17.25	98.12±16.38	**0.243ns**

P=0.05, ns: not significant at P>0.05

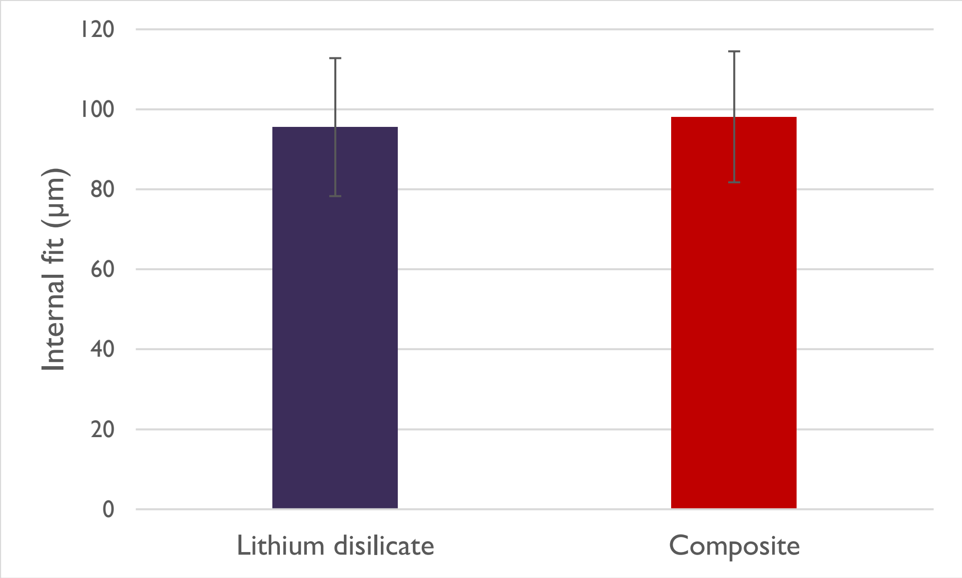

Figure 2: Bar chart showing internal fit mean values (µm) for both groups.

4. DISCUSSION

Dental bonded restorations represent significant advancements in materials science aimed at preserving healthy tooth structure during conservative treatment. This approach minimizes the removal of natural tooth material and eliminates the need for mechanical locks, resulting in more durable restorations. However, concerns regarding polymerization shrinkage and technique sensitivity remain prevalent for this type of restoration.(14)

New CAD/CAM technology addresses the limitations of direct restorations by utilizing pre-polymerized blocks, effectively resolving the issue of polymerization shrinkage. Additionally, the enhanced mechanical properties resulting from a higher filler content, along with improved marginal adaptation, render it superior to traditional bonded restorations.(15)

Marginal gap measurement is the most critical factor for the success of indirect restoration. The accuracy of the restoration fit is deemed clinically acceptable at 120 µm or less.(13,16,17)

Among the various types of dental ceramics, lithium disilicate is commonly used in indirect restorations due to its superior mechanical properties compared to traditional dental porcelains, as well as its high strength and notable fracture toughness (18). The use of advanced lithium disilicate CEREC TESSERA offers enhanced strength and minimizes marginal chipping due to its composition of lithium disilicate and virgilite. This composition allows the blocks to fire quickly and reduces shrinkage during post-milling crystallization. (19–21)

Brilliant Crios composite blocks came with many more advantages than traditional composites, as they had more flexural strength and low abrasiveness with no firing steps, which reduced shrinkage and led to better marginal adaptation.

The findings of the present study revealed that both restoration types showed marginal gap values that were within clinically acceptable limits. Although the composite group showed slightly larger gaps on average compared to the lithium disilicate group, the difference was not statistically significant ($p > 0.05$). These results support earlier research indicating that lithium disilicate generally offers a superior marginal fit, likely due to its excellent milling accuracy and consistent behavior during manufacturing and cementation (22,23). Its physical properties ensure a more precise fit to the tooth structure, which may explain its relatively enhanced performance. However, the composite overlays also performed well. Despite exhibiting slightly larger marginal gaps, they remained within acceptable clinical range. This highlighted their potential reliability as a viable alternative, especially in situations where a more forgiving, repairable, or shock-absorbing material is required. (23)

Another explanation for this finding was that the resin cement utilized in this study had a low film thickness, which positively influenced the seating of the restoration and consequently resulted in a better marginal fit (24,25). The biocompatibility of the cement used with the universal prime and bond, without the need for an additional activator step, had led to better bonding and optimal marginal adaptation. (26) Furthermore, good finishing and polishing protocol following the manufacturer's instructions decreased the gap between two types of blocks as they achieved the ideal marginal adaptation (7,27).

Regarding internal fit, both composite and lithium disilicate groups showed comparable results. This finding may be linked to the simplified design of the cavity preparation, as non-retentive preparations demonstrated better marginal and internal adaptation and facilitated the flow of the cement compared to geometrical preparations (13,28,29).

Finally, marginal and internal fit may be influenced by various factors, including cavity preparation, milling machine, type of scanner, cement material, and the pressure applied during cementation. Any alterations to these variables could yield different results and warrant further investigation in future research. (30,31)

5. CONCLUSIONS

Based on the findings of this study and within its limitations, the following conclusions can be listed:

1. Composite CAD/CAM blocks showed similar marginal and internal adaptation results as lithium disilicate blocks.
2. Composite CAD/CAM blocks considered to be suitable materials for indirect overlay restorations.
3. Marginal and internal gap of both groups fell within the clinically acceptable range.

6. RECOMMENDATIONS

1. Further research should be carried out to evaluate marginal and internal fit of different indirect restoration materials and cavity configurations.

2. Randomized controlled clinical trials (RCTs) should be carried out to approve our findings.

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