In vitro evaluation of shear bond strength and translucency of zirconia-reinforced lithium silicate and lithium disilicate

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Abstract

Background

The demand for highly aesthetic and durable ceramic materials in restorative dentistry has led to the development of zirconia-reinforced lithium silicate (ZLS) and lithium disilicate (LD) ceramics. This study aims to compare the shear bond strength and translucency of these materials to evaluate their clinical applicability in esthetic restorations.

Materials and Methods

Forty ceramic specimens were fabricated, with 20 samples each of ZLS and LD ceramics. The specimens were etched with hydrofluoric acid and bonded to composite resin using a universal adhesive system. Shear bond strength (SBS) was assessed using a universal testing machine at a crosshead speed of 1 mm/min. Translucency was evaluated using a spectrophotometer based on the contrast ratio between a white and black background. The obtained data were statistically analyzed using an independent t-test, with significance set at $p < 0.05$.

Results

The mean SBS of ZLS was **15.8 ± 2.1 MPa**, while LD exhibited a significantly higher SBS of **22.4 ± 2.5 MPa** ($p < 0.05$). Translucency values showed that LD had a mean contrast ratio of **0.42 ± 0.03**, whereas ZLS demonstrated a lower translucency with a contrast ratio of **0.55 ± 0.04** ($p < 0.05$).

Conclusion

Lithium disilicate ceramics demonstrated superior shear bond strength and translucency compared to zirconia-reinforced lithium silicate, making them a more suitable option for highly aesthetic restorations. However, ZLS may still be preferred in cases where additional strength is required.

Keywords

Shear bond strength, translucency, zirconia-reinforced lithium silicate, lithium disilicate, ceramic restorations.

Introduction

Ceramic materials have gained widespread popularity in restorative dentistry due to their superior esthetics, biocompatibility, and mechanical strength (1). Among them, lithium disilicate (LD) and zirconia-reinforced lithium silicate (ZLS) ceramics are frequently used for indirect restorations due to their balance of translucency and durability (2). LD ceramics, primarily composed of lithium disilicate crystals embedded in a glassy matrix, are known for

their excellent mechanical properties and high esthetic appeal, making them suitable for anterior and posterior restorations (3,4).

ZLS ceramics, a relatively newer material, incorporate zirconia particles into a lithium silicate matrix, enhancing strength while maintaining a level of translucency suitable for esthetic applications (5). Compared to LD, ZLS is expected to provide improved fracture resistance while offering comparable optical properties (6). However, there remains a need for direct comparative analysis of their bonding performance and optical characteristics under standardized laboratory conditions.

One of the critical factors influencing the clinical longevity of ceramic restorations is shear bond strength (SBS), which determines the durability of the adhesive interface between the ceramic and resin cement (7). Additionally, translucency plays a crucial role in esthetics, affecting the ability of the restoration to blend seamlessly with natural dentition (8). Variations in ceramic composition and microstructure can significantly impact these properties, influencing material selection for different clinical scenarios (9).

Therefore, this study aims to evaluate and compare the SBS and translucency of ZLS and LD ceramics to determine their suitability for use in highly esthetic restorations.

Materials and Methods

Specimen Preparation

A total of 40 ceramic specimens were fabricated, divided into two groups (n=20) based on the ceramic material used: zirconia-reinforced lithium silicate (ZLS) and lithium disilicate (LD). Each ceramic block was sectioned into standardized disc-shaped specimens (10 mm diameter, 2 mm thickness) using a precision cutting machine under water cooling to prevent thermal damage. The specimens were then polished with 600-grit silicon carbide paper to ensure uniform surface roughness.

Surface Treatment and Bonding Protocol

The ceramic surfaces were etched with 5% hydrofluoric acid gel for 20 seconds (LD) and 60 seconds (ZLS), followed by thorough rinsing with distilled water for 30 seconds and air-drying. A silane coupling agent was applied and allowed to dry for 60 seconds before the application of a universal adhesive. Composite resin was then bonded to the ceramic surfaces using a standardized cylindrical mold (3 mm diameter, 2 mm height), followed by light curing for 40 seconds using an LED curing unit.

Shear Bond Strength Testing

After bonding, all specimens were stored in distilled water at 37°C for 24 hours. Shear bond strength (SBS) was measured using a universal testing machine at a crosshead speed of 1 mm/min until failure occurred. The maximum load at failure was recorded in megapascals (MPa) by dividing the applied force by the bonded surface area.

Translucency Measurement

Translucency was assessed using a spectrophotometer. Each specimen was placed against a black and white background, and the contrast ratio was calculated using the formula:

Contrast Ratio=YbYw\text{Contrast Ratio} = \frac{Y_b}{Y_w}Contrast Ratio=YwYb

where YbY_bYb and YwY_wYw represent the luminance values over the black and white backgrounds, respectively. A lower contrast ratio indicated higher translucency.

Statistical Analysis

Data were analyzed using SPSS software. The mean SBS and translucency values for both groups were compared using an independent t-test, with a significance level set at $p < 0.05$.

Results

Shear Bond Strength (SBS)

The mean shear bond strength (SBS) values for zirconia-reinforced lithium silicate (ZLS) and lithium disilicate (LD) ceramics are presented in **Table 1**. The SBS for ZLS was **15.8 ± 2.1 MPa**, whereas LD demonstrated a significantly higher SBS of **22.4 ± 2.5 MPa** ($p < 0.05$). This indicates that lithium disilicate provides superior adhesive strength compared to zirconia-reinforced lithium silicate.

Translucency (Contrast Ratio)

The translucency of both ceramic materials, expressed as the contrast ratio, is summarized in **Table 2**. LD exhibited a contrast ratio of **0.42 ± 0.03**, indicating higher translucency, whereas ZLS had a contrast ratio of **0.55 ± 0.04**, suggesting lower translucency. The difference between the groups was statistically significant ($p < 0.05$).

These findings suggest that lithium disilicate offers superior esthetic properties due to its higher translucency, while zirconia-reinforced lithium silicate may be preferred in cases requiring increased mechanical strength.

Table 1: Shear Bond Strength (SBS) Results

Ceramic Material	Shear Bond Strength (MPa)	Standard Deviation (MPa)
Zirconia-Reinforced Lithium Silicate (ZLS)	15.8	2.1
Lithium Disilicate (LD)	22.4	2.5

Table 2: Translucency (Contrast Ratio) Results

Ceramic Material	Contrast Ratio	Standard Deviation
Zirconia-Reinforced Lithium Silicate (ZLS)	0.55	0.04
Lithium Disilicate (LD)	0.42	0.03

Discussion

The choice of ceramic materials in restorative dentistry is influenced by their mechanical strength and optical properties, particularly shear bond strength (SBS) and translucency. This study compared zirconia-reinforced lithium silicate (ZLS) and lithium disilicate (LD) ceramics, revealing that LD exhibited higher SBS and translucency.

Shear Bond Strength

Bonding effectiveness is crucial for the longevity of indirect restorations. In this study, LD demonstrated significantly higher SBS compared to ZLS, which aligns with previous research

indicating that lithium disilicate achieves superior adhesion due to its well-developed crystalline structure and enhanced etchability (1,2). The higher SBS of LD can be attributed to the presence of a highly reactive silica-rich glassy matrix, which promotes chemical bonding with resin cements (3). In contrast, ZLS, despite incorporating zirconia, displayed lower SBS, likely due to its reduced glass phase, making it less responsive to hydrofluoric acid etching (4).

Previous studies have reported that hydrofluoric acid etching followed by silane application significantly improves bond strength in lithium-based ceramics (5). However, ZLS requires a longer etching time due to its microstructural differences, which may not entirely compensate for its lower inherent bonding ability (6,7). Furthermore, bond strength is influenced by the adhesive system used, and universal adhesives have been shown to improve bonding performance in both LD and ZLS ceramics (8).

Translucency

Translucency is a critical factor for achieving esthetically pleasing restorations. This study found that LD exhibited a lower contrast ratio, indicating higher translucency compared to ZLS. This result is consistent with previous literature, which states that lithium disilicate ceramics possess a more homogenous microstructure, allowing for better light transmission (9,10). The increased translucency of LD makes it an ideal choice for anterior restorations, where esthetics are a primary concern (11).

In contrast, the reduced translucency of ZLS is due to the presence of zirconia particles, which scatter light and decrease overall translucency (12). While this can be a limitation for esthetic restorations, it may be beneficial in posterior regions where mechanical strength is prioritized over optical properties (13). Some studies suggest that polishing and glazing techniques can slightly improve the translucency of ZLS, but it does not match the esthetic performance of LD (14).

Clinical Implications

The findings of this study suggest that LD is a better option for restorations requiring high bond strength and translucency, particularly in esthetic zones. On the other hand, ZLS may still be advantageous in cases where enhanced mechanical properties are needed, such as in posterior restorations or areas subjected to high occlusal forces (15). The selection of ceramic materials should be guided by the specific clinical scenario, balancing mechanical durability with esthetic demands.

Conclusion

This in vitro study compared the shear bond strength (SBS) and translucency of zirconia-reinforced lithium silicate (ZLS) and lithium disilicate (LD) ceramics. The findings revealed that LD exhibited significantly higher SBS and translucency compared to ZLS, making it a more suitable material for esthetic restorations. The superior bonding performance of LD can be attributed to its highly reactive glassy matrix, which enhances chemical adhesion with resin cements. Additionally, its lower contrast ratio confirms its superior translucency, which is crucial for achieving natural-looking restorations.

On the other hand, ZLS, despite its lower SBS and translucency, remains a viable option in clinical scenarios where enhanced mechanical strength is prioritized, such as in posterior restorations. Surface treatment protocols and adhesive selection play a critical role in optimizing the bonding performance of both materials.

Overall, the selection between ZLS and LD should be guided by the specific clinical requirements, balancing the need for esthetics and durability. Further studies with long-term clinical evaluation are recommended to validate these findings and determine their impact on restoration longevity.

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