FLUORESCENCE EFFECT OF CAD/CAM HYBRID CERAMIC AND LITHIUM DISILICATE GLASS CERAMIC

Ploypailin JUMPATHONG[1], Wisarut PRAWATVATCHARA[2] and Niyom THAMRONGANANSKUL[2]

1 Graduate Student, Faculty of Esthetic Restorative and Implant Dentistry Program, Faculty of Dentistry, Chulalongkorn University, Thailand; ploy17894@gmail.com

2 Department of Prosthodontics, Faculty of Dentistry, Chulalongkorn University, Thailand; wisarut.p@chula.ac.th (W. P.); niyom.t@chula.ac.th (N. T.)

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ABSTRACT

Limited data are available regarding the fluorescence properties of CAD/CAM lithium disilicate ceramics and hybrid ceramic, despite their importance in achieving natural esthetic dental restorations. Variations in fluorescence among IPS e.max CAD, Amber Mill, Rosetta SM, VITA Enamic, and Cerasmart may influence esthetic outcomes under different lighting conditions. The purpose of this study was to evaluate the fluoresence effect of material type of CAD/CAM lithium disilicate and hybrid ceramics. A total of 50 CAD/CAM lithium disilicate and hybride ceramic specimens were fabricated from IPS e.max CAD, Amber Mill, Rosetta SM, VITA Enamic, and Cerasmart at 1.0 mm thickness. A resin cement substrate (RelyX U200) was used as contol. All specimens was prepared and at $10 \times 10 \times 1$ mm^3 in size. All specimens were polished using sequential 800 and 1400-grit silicon carbide papers, and final thicknesses were verified with a digital caliper. Fluorescence-related color differences (ΔE_{00}) were measured using a spectrophotometer and calculated with the CIEDE2000 formula. Data were analyzed using one-way ANOVA and least significant difference post-hoc tests ($\alpha = .05$). At 1-mm thickness, lithium disilicate ceramics exhibited significantly higher fluorescence differences (ΔE_{00}) than hybrid ceramics ($p < 0.05$), with no significant differences within each material group.

Keywords: CAD/CAM, Lithium Disilicate, Hybrid Ceramic, Fluorescence, Thickness, CIEDE2000, Spectrophotometer

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INTRODUCTION

Increasing patient demand for esthetic outcomes has driven advancements in ceramic restorative materials, which are favored for their ability to replicate natural tooth structure (Filho et al., 2004). Modern chairside CAD/CAM systems further enhance efficiency, patient comfort, and esthetic results (Pop-Ciutrila et al., 2021; Chui, 2020). In addition to glass-ceramic materials, hybrid ceramics were developed to combine the esthetic properties of ceramics with the mechanical resilience of resin composites. Their dual-network structure, consisting of a ceramic matrix infiltrated with a polymer phase, improves machinability and stress distribution while maintaining acceptable optical properties (Blackburn et al., 2018). However, the optical behavior of hybrid ceramics, including fluorescence, differs from that of conventional glass ceramics and is strongly influenced by material composition and thickness (Hashemikamangar et al., 2021).

Luminescence occurs when excited electrons return to a lower energy state, while fluorescence specifically involves absorption of ultraviolet light and emission at a longer wavelength (Lee, 2015). Natural teeth exhibit bluish-white fluorescence within the 400-650 nm range under UV light (Wozniak & Moore, 1978), and modern restorative materials such as resin composites, porcelains, lithium disilicate, zirconia, and hybrid ceramics are designed to replicate this property.

Dental ceramics achieve fluorescence through the incorporation of rare earth oxides such as cerium, europium, terbium, ytterbium, dysprosium, and samarium (Hashemikamangar et al., 2021; Baran et al., 1977; Revilla-León et al., 2021). Restoration thickness also significantly affects fluorescence intensity (Lee et al., 2005; Rafael et al., 2017), and variations in anterior preparation thickness may therefore influence clinical fluorescence outcomes.

RelyX U200 is a dual-cure, self-adhesive resin cement that can influence the final color and fluorescence of indirect restorations, particularly in thin restorations where the substrate effect is significant. Resin cement type has been shown to affect fluorescence-related color appearance under ultraviolet or fluorescence-enhanced lighting (Turgut & Bagis, 2013; Hoorizad et al., 2021).

Fluorescence characteristics of anterior restorative materials vary by material type (Tabatabaei et al., 2019), and only limited studies have evaluated fluorescence in current ceramic and hybrid ceramic systems (Hashemikamangar et al., 2021; Rafael et al., 2017; Silami et al., 2019; Rafael et al., 2018). To the authors' knowledge, no previous study has specifically investigated the fluorescence behavior of lithium disilicate and hybrid ceramic restorations when placed on a fluorescent substrate, highlighting a gap in the literature.

Therefore, the aim of this study was to evaluate the fluorescence effects of different CAD/CAM lithium disilicate materials and hybrid ceramic which are IPS e.max CAD, Amber Mill, Rosetta SM, VITA Enamic, and GC Cerasmart.

The null hypothesis was that there is no significant difference in the fluorescence color difference (ΔE_{00}) among the various types of CAD/CAM lithium disilicate materials and hybrid ceramic (IPS e.max CAD, Amber Mill, Rosetta SM, VITA Enamic, and GC Cerasmart)

LITERATURE REVIEWS

Overview of Fluorescence Properties

Fluorescence is a critical optical property in esthetic dentistry, influencing how restorations appear under ultraviolet and natural light. The ability to replicate natural tooth fluorescence is essential for achieving lifelike outcomes (Trivedi et al., 2025). Among CAD/CAM materials, lithium disilicate and hybrid ceramics differ in fluorescence due to their distinct compositions and microstructures. Lithium disilicate demonstrates superior fluorescence and higher translucency (TP = 16.53) compared with hybrid ceramics such as VITA Enamic (TP = 11.70), which contributes to its closer approximation to natural enamel (Hashem et al., 2025).

Optical Properties and Fluorescence Characteristics

Fluorescence emission is influenced by material composition and crystalline structure. Lithium disilicate glass ceramics contain lithium metasilicate and lithium disilicate crystals within a glass matrix, enabling efficient absorption and reemission of ultraviolet light and resulting in stronger fluorescence (Tavares et al., 2025). In contrast, hybrid ceramics such as VITA Enamic possess a dual-network ceramic-polymer structure (Andriyani et al., 2017); although this enhances mechanical properties, the polymer phase reduces fluorescence output due to different UV absorption behavior (Killedar et al., 2025). Surface treatments also affect fluorescence, with glazing enhancing fluorescence more effectively than polishing in lithium disilicate, while hybrid ceramics show less pronounced improvement (Hashemikamangar et al., 2022; Vasiliu et al., 2020).

Effect of Material Thickness and Surface Treatment

Fluorescence decreases with increasing thickness, although lithium disilicate maintains higher fluorescence than hybrid ceramics at all thicknesses (Hashem et al., 2025). Glazing enhances and stabilizes fluorescence in lithium disilicate (Furini et al., 2024), while hybrid ceramics show improvement after polishing and glazing but remain lower overall (Aladağ & Ayaz, 2024).

Stability and Degradation of Fluorescence over Time

Fluorescence stability is essential for long-term esthetic success. Lithium disilicate demonstrates greater resistance to staining and aging compared with hybrid ceramics (Hashem et al., 2025). After exposure to dietary stains, lithium disilicate retains approximately 75-78% of its initial fluorescence, whereas hybrid ceramics retain about 55-60% (Demir et al., 2024). Similarly, thermocycling results in minimal fluorescence reduction in lithium disilicate but more pronounced decline in hybrid ceramics, likely due to differences in microstructural stability (Vasiliu, 2020).

Impact of Color Stability on Fluorescence Perception

Color stability affects fluorescence perception and esthetics. Lithium disilicate shows superior color stability ($\Delta E = 2.45$), maintaining fluorescence over time, whereas hybrid ceramics exhibit greater color change ($\Delta E = 3.02$), which may reduce esthetic integration (Hashem et al., 2025).

Clinical Relevance and Material Selection

Lithium disilicate is preferred for anterior restorations due to its enamel-like fluorescence and stability after aging (Monteriro et al., 2012). Hybrid ceramics, with lower fluorescence, are more suitable when mechanical durability is prioritized, particularly in posterior regions (Pacharaporn et al., 2025).

Natural Tooth Fluorescence Reference

Natural enamel exhibits peak fluorescence around 430-440 nm under ultraviolet light, while dentin shows approximately three times greater fluorescence intensity (Lee, 2015). Lithium disilicate ceramics more closely replicate enamel fluorescence than hybrid ceramics, supporting improved bioesthetic integration (Kim, 2020).

RESEARCH METHODOLOGY

Table 1 Manufacturer information for the CAD/CAM lithium disilicate ceramic and hybrid ceramic materials used in this study

Group	Material	Manufacturer	Shade	Compositions (wt%)	Crystallization temperature
EM	IPS e.max CAD	Ivoclar, Vivadent, Schaan, Liechtenstein	HT A2	SiO_2: 57-80% Li_2O: 11-19% K_2O: 0-13% P_2O_5: 0-11% ZrO_2 and ZnO: 0-8% Coloring oxides: 0-12%	850 °C
AM	Amber Mill	HASSBio, Kangneung, Korea	HT A2	SiO_2: <78% Li_2O: <12% Coloring oxides: <12%	815 °C (for HT)
RT	Rosetta SM	HASSBio, Kangneung, Korea	HT A2	SiO_2: <78% Li_2O: <12% Coloring oxides: <12%	840 °C
VE	VITA Enamic	Vita Zahnfabrik, Bad Säckingen, Germany	HT 2M2	SiO_2: 58-63% Al_2O_3: 20-23% Na_2O: 9-11% K_2O: 4-6% B_2O_3: 5.9% ZrO_2 and CaO: <1%	No additional crystallization required
CS	Cerasmart (PICN hybrid ceramic)	GC Europe, Leuven, Belgium	HT A2	Bis-MEPP, UDMA, DMA, and 71 % silica and barium glass nano-particles by weight	No additional crystallization required
C	RelyX U200	3M ESPE, Seefeld, Germany		Base: Methacrylate monomers containing phosphoric acid groups, methacrylate monomers, initiators, stabilizers, rheological additives. Catalyst: Methacrylate monomers, alkaline fillers, silanated fillers, Initiator components, stabilizers, pigments, rheological additives. Zirconia/silica fillers.	

PICN, polymer-infiltrated ceramic-network material; Bis-MEPP, 2, 2-Bis (4-methacryloxypolyethoxyphenyl) propane; UDMA, urethane dimethacrylate; DMA, dimethacrylate;

In Specimen preparation

RelyX U200 resin cement (3M ESPE, Seefeld, Germany) was used to simulate natural dentin fluorescence. Specimens were fabricated in a silicone mold, covered with celluloid strips and a glass slide for standardization, and light-cured for 40 seconds using an LED curing unit (Bluephase N; Ivoclar AG) at 650-1200 mW/cm².

Specimens were polished to a final thickness of 1 mm using 800- and 1400-grit silicon carbide papers under running water via a polishing machine (NANO 2000, Pace Technologies, USA), and thickness was verified with a digital caliper to achieve dimensions of 10 × 10 × 1 mm³. The samples were ultrasonically cleaned for 4 minutes and stored in distilled water for 24 hours before testing (Silami et al., 2019). The thickness of the resin cement specimen was subsequently done by digital vernier caliper (Mitutoyo, Tokyo, Japan) to ensure a final dimension of 10 x 10 x 1 mm³. The samples were ultrasonically cleaned for 4 minutes and stored in distilled water for 24 hours before testing (Silami et al., 2019).
Five different prefabricated CAD/CAM lithium disilicate and hybride ceramic blocks from Table 1 were prepared into a square shape. The samples were cut with a low speed cutting machine (ISOMET 1000 BUEHLER, USA) with a water coolant into 10 x 10 x 1 mm³. Premium silicon carbide abrasive paper with 800 and 1400 grits was used for the polishing process. Crystallization was performed according to the manufacturer's recommendation in a furnace (Programat P700, Ivoclar, Vivadent, Schaan, Liechtenstein). The final thickness of each specimen was measured by a digital caliper to be within 0.05 mm and any defective discs were discarded. The prepared specimens were cleaned with 90% ethanol in an ultrasonic bath for 4 minutes (Silami et al., 2019). The samples were stored under dry conditions before testing. The process of the study design is as shown in Figure 1.

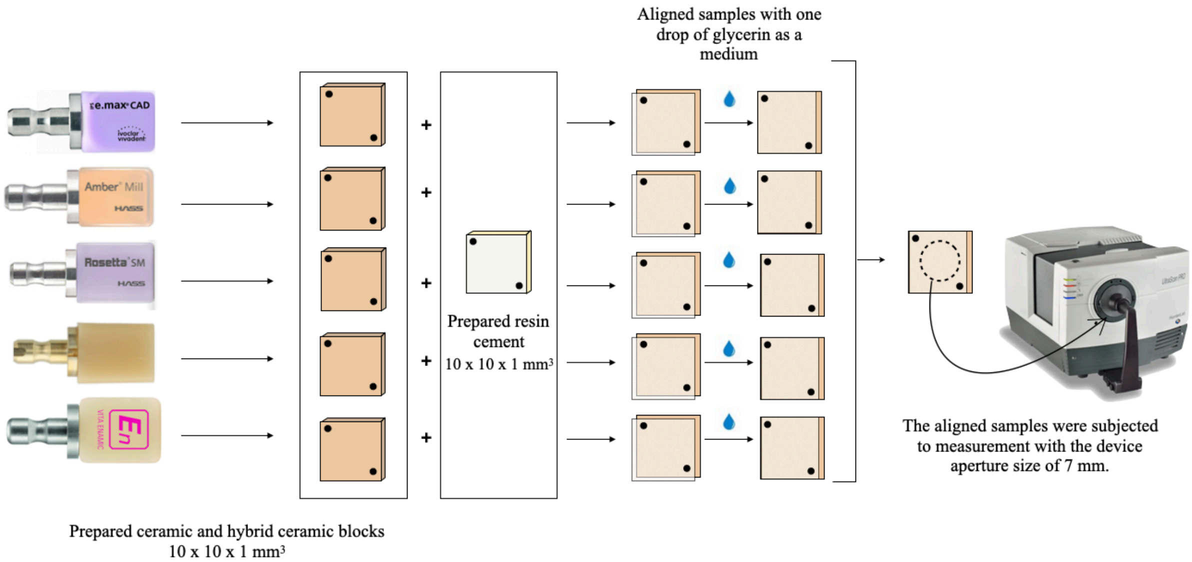

Figure 1 Study design and experimental method of this study

Specimens were marked at two corners to standardize measurement areas. A drop of glycerin was applied between the resin cement and each specimen to ensure optimal adaptation before spectrophotometric evaluation (Rafael et al., 2017). The spectral reflectances of all specimens was measured under laboratory conditions by a spectrophotometer (UltraScan PRO; Reston, VA, USA) with a 7 mm device aperture.
Calibration followed the manufacturer's guidelines, employing the reflectance specular excluded mode with UV included and standardized using a fluorescence standard. Measurements were taken under D65 illumination conditions with a 10° standard observer against a white background.
Measurements were performed by a single operator and color differences were calculated by the Commission Internationale de l'Éclairage (CIE) formula (Revilla-León et al., 2021; Rafael, 2018; Aneksomboonpol et al., 2024): Compared with the CIELab formula, the CIEDE2000 formula was selected for this study because it provides a more accurate representation of color differences as perceived by the human eye (Gómez-Polo et al., 2016).

$\Delta E_{00} = \{[\Delta L'/(k_L S_L)]^2 + [\Delta C'/(k_C S_C)]^2 + [\Delta H'/(k_H S_H)]^2 + R_T[\Delta C'/(k_C S_C)] \text{ X } [\Delta H'/(k_C S_C)]\}^{1/2}$.
In the CIEDE2000 formula, ΔL', ΔC', and ΔH' represent differences in lightness, chroma, and hue, respectively. SL, SC, and SH are weighting functions that adjust these components according to human visual perception, while KL, KC, and KH are parametric factors related to viewing conditions. RT is a correction term accounting for the interaction between chroma and hue differences, particularly in highly saturated colors.
The sample size was analyzed using the G*power program (Version 3.1.9.7, Hein-rich-Heine Dusseldorf University, Dusseldorf, Germany). Based on the pilot investigation, 50 samples were found (effect size f = 0.65, α err prob = 0.05, power (1− β err prob) = 0.95, number of groups = 5). Therefore, ten samples were required for each group. IBM SPSS. V29.0.1 (SPSS Inc., Chicago, IL, USA) was used to evaluate the quantitative data from the five separate groups at a 95% confidence level. Normality was assessed using the Shapiro-Wilk test ($p < 0.05$). The equality of variation was then examined using Levene's test. The data had equal variance and a normal distribution, according to the findings. Consequently, the data was calculated using a one-way ANOVA and the differences between groups were then ascertained using a post hoc Tukey test ($p < 0.05$).

RESEARCH RESULTS

Table 2 summarizes the average mean and standard deviation of the color difference in the fluorescence (ΔE_{00}) of each CAD/CAM lithium disilicate material and hybrid ceramic at 1 mm thickness.

Table 2 shows the mean and standard deviation of ΔE_{00} of five tested materials.

	EM	AM	RT	VE	CS
ΔE_{00}	1.807 ± 0.222^A	1.599 ± 0.223^A	1.714 ± 0.227^A	1.182 ± 0.226^B	1.078 ± 0.207^B

The uppercase letter differences represent significant differences at $p < 0.05$

At 1 mm thickness, the fluorescence-related color difference (ΔE_{00}) varied among the tested materials. Overall the mean ± standard deviation values ranged from 1.078 to 1.807.
The highest mean ΔE_{00} was observed for EM, followed by RT and AM, whereas CS showed the lowest mean ΔE_{00}, followed by VE. According to the superscript letter grouping, EM, AM, and RT shared the same uppercase letter (A), indicating no statistically significant differences among these lithium disilicate materials ($p > 0.05$). In contrast, VE and CS shared a different uppercase letter (B), indicating no statistically significant difference between the two hybrid ceramic materials ($p > 0.05$).
However, the materials in group A demonstrated significantly higher ΔE_{00} values than those in group B ($p < 0.05$). This finding indicates that, at 1 mm thickness, the tested lithium disilicate CAD/CAM materials exhibited greater fluorescence-related color differences compared with the tested hybrid ceramic materials under the conditions of this study.

DISCUSSION & CONCLUSION

The results demonstrated that fluorescence-related color difference (ΔE_{00}) was significantly influenced by material type, with higher ΔE_{00} values observed for lithium disilicate ceramics compared with hybrid ceramics when placed on a fluorescent resin cement substrate. Significant differences were identified between the lithium disilicate materials and the hybrid ceramic materials, whereas no significant differences were found among the lithium disilicate materials or between the hybrid ceramics. Therefore, the first null hypothesis of this study, that there is no significant difference in the fluorescence color difference (ΔE_{00}) among the various types of CAD/CAM lithium disilicate materials and hybrid ceramics (IPS e.max CAD, Amber Mill, Rosetta SM, VITA Enamic, and GC Cerasmart), was partially rejected, as significant

differences were observed between lithium disilicate and hybrid ceramic materials, while no significant differences were found within each material category.
The use of a standardized 1.0 mm thickness in this study was intended to ensure strict control of variables and methodological consistency, as all specimens were fabricated and verified at identical dimensions prior to measurement. Although clinical restorations may vary in thickness, previous evidence indicates that reduced thickness can increase the influence of the underlying substrate on fluorescence intensity (Revilla-León et al., 2021). Therefore, thinner restorations may demonstrate greater interaction between the ceramic and the fluorescent base. RelyX U200 was selected as a standardized fluorescent substrate to simulate dentin-like optical behavior; however, future studies incorporating different thicknesses and direct comparison with natural dentin would further strengthen the clinical relevance of the findings.
Although fluorescence differences were quantified under standardized conditions, the variations among materials may be related to differences in composition and microstructure. In particular, the type and concentration of rare earth oxides incorporated into lithium disilicate and hybrid ceramic matrices may influence their fluorescence behavior (Hashemikamangar et al., 2021; Baran et al., 1977; Revilla-León et al., 2021). As these components were not chemically analyzed in this study, future research evaluating rare earth additives and their interaction with specific material structures is recommended to provide a clearer scientific explanation of the observed fluorescence differences.
The CIE system uses spectrophotometry to standardize and quantify color differences based on reflected light. In 2001, the CIEDE2000 (ΔE_{00}) formula was introduced to improve the accuracy of color difference measurements compared with the earlier CIELab method, particularly for complex color variations and fluorescence-related differences (Gómez-Polo et al., 2016). In the present study, ΔE_{00} was used to evaluate fluorescence-related shade variations by analyzing differences in lightness ($\Delta L'$), chroma ($\Delta C'$), and hue ($\Delta H'$), allowing for a more precise assessment of color changes.
Fluorescence is an essential optical property for achieving esthetic dental restorations that closely resemble natural teeth under both ultraviolet and natural lighting conditions. In the present study, fluorescence-related color differences (ΔE_{00}) were significantly influenced by material type, with lithium disilicate ceramics demonstrating higher ΔE_{00} values than hybrid ceramics when placed on a fluorescent resin cement substrate. These findings are consistent with previous reports indicating that lithium disilicate glass ceramics exhibit superior fluorescence behavior compared with hybrid ceramic materials (Trivedi et al., 2025; Hashem et al., 2025).
The enhanced fluorescence observed in lithium disilicate ceramics may be attributed to their glass-ceramic microstructure, which consists of lithium disilicate crystals embedded in a glassy matrix. This structure facilitates efficient absorption and re-emission of ultraviolet light, resulting in fluorescence characteristics that more closely approximate those of natural enamel (Tavares et al., 2025). In contrast, hybrid ceramics contain an interpenetrating network of ceramic and polymer phases. Although this dual-network structure improves mechanical performance and resilience, the polymer component may attenuate ultraviolet excitation, leading to reduced fluorescence output (Andriyani et al., 2017; Killedar et al., 2025).
RelyX U200, a dual-cure self-adhesive resin cement, was selected as the fluorescent substrate because resin-based luting agents are reported to exhibit tooth-like fluorescence similar to natural dentin. Resin cements can influence the overall fluorescence and optical behavior of ceramic restorations, particularly in thin restorations under ultraviolet or fluorescence-enhanced lighting (Hoorizad et al., 2021). According to the manufacturer (Solventum), RelyX U200 demonstrates fluorescence properties designed to approximate natural tooth structure.
Surface treatments have also been shown to influence fluorescence behavior. Previous studies reported that glazing enhances the fluorescence of ceramic materials more effectively than

polishing alone, particularly for lithium disilicate ceramics (Hashemikamangar et al., 2022; Furini et al., 2024). Hybrid ceramics, however, tend to exhibit less pronounced fluorescence enhancement following glazing and polishing procedures (Vasiliu et al., 2020; Aladağ & Ayaz, 2024). Although surface treatments were not evaluated in the present study, these findings highlight the importance of finishing protocols in optimizing the final esthetic appearance of restorations.

Material thickness is another factor known to affect fluorescence intensity. Prior investigations have demonstrated a reduction in fluorescence with increasing restoration thickness for both lithium disilicate and hybrid ceramics (Hashem et al., 2025). Nevertheless, lithium disilicate materials have been reported to maintain higher fluorescence levels across clinically relevant thicknesses compared with hybrid ceramics. This characteristic is particularly relevant for anterior restorations, where minimal thickness is often required to preserve tooth structure while achieving optimal esthetics.

The long-term stability of fluorescence is also critical for maintaining esthetic outcomes. Lithium disilicate ceramics have been shown to exhibit greater resistance to fluorescence degradation following exposure to staining agents and aging protocols, such as thermocycling, compared with hybrid ceramics (Vasiliu et al., 2020; Demir et al., 2024). The superior stability of lithium disilicate may be related to the inherent durability of its crystalline glass-ceramic structure, whereas hybrid ceramics may be more susceptible to microstructural changes over time due to their polymer component.

In clinical practice, restorations are subjected to variable thicknesses, diverse underlying substrates (enamel, dentin, or discolored cores), and different lighting environments, all of which may influence fluorescence perception. The present findings indicate that lithium disilicate materials, which demonstrated higher fluorescence-related color differences, may be more suitable for esthetically demanding anterior restorations where precise biomimetic integration is required. From a clinical perspective, lithium disilicate ceramics more closely approximate the fluorescence characteristics of natural enamel, which exhibits peak emission in the blue region of the spectrum, while dentin demonstrates even greater fluorescence intensity (Lee, 2015; Kim, 2020). In contrast, hybrid ceramics, although offering advantages in fracture resistance and fatigue performance (Pacharaporn, 2025), may be more appropriate in situations where mechanical durability is prioritized over optimal fluorescence reproduction. By linking laboratory findings to variations in restoration thickness, substrate influence, and functional demands, this study provides clinically relevant guidance for material selection under real intraoral conditions.

Within the limitations of the analyzed dataset, material type significantly influenced fluorescence-related color differences (ΔE_{00}) when CAD/CAM restorative materials were placed on a fluorescent resin cement substrate. Lithium disilicate ceramics exhibited significantly higher ΔE_{00} values than hybrid ceramics, indicating greater fluorescence interaction and visibility. In contrast, hybrid ceramics demonstrated lower fluorescence-related color differences**,** which may affect their esthetic performance under ultraviolet or fluorescence-enhanced lighting conditions.

This study was conducted under controlled experimental conditions. Resin cement and glaze paste were not included, which may have influenced the measured ΔE_{00} values. Only a single shade and one material thickness were evaluated, which may limit the findings. Aging procedures were not performed, although aging may affect fluorescence over time. In addition, variations in translucency and opacity were not assessed.

Further research is necessary to examine additional clinical variables that may influence fluorescence-related color differences. The effects of resin cement, glaze paste, different shades, and restoration thicknesses should be investigated to improve clinical applicability. Aging procedures, including thermocycling should also be incorporated to assess changes in fluorescence over time. Furthermore, surface treatments such as glazing and polishing, along with repeated sintering or crystallization cycles, should be evaluated in future studies, as they may alter fluorescence intensity and affect the final, natural appearance of restoration.

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