Khalij Libya Journal of Dental and Medical Research. 2025;9(2):308-311
https://doi.org/10.47705/kjdmr.259225
eISSN:2708-888X

Original article

Comparative Analysis of Acid-Induced Surface Roughness in Lithium Disilicate and Hybrid CAD/CAM Fixed Prosthodontics Materials

Milad Elshah[1], Asmaa Abdeewi[2,3]*, Mohamed Zeglam[4]

[1]*School of Medical Science, Libyan Academy for Postgraduate Studies, Janzour, Libya*
[2]*Libyan Polymer Research Center, Tripoli, Libya, Research and Consultancy Center, Sirte University, Sirte, Libya*
[3]*Research and Consultancy Center, Sirte University, Sirte, Libya*
[4]*Department of Fixed Prosthodontics, Faculty of Dentistry, University of Tripoli, Tripoli, Libya*
***Corresponding Email**. asmaa.abdeewi@prc.ly*

Abstract
The surface integrity of CAD/CAM restorative materials is critical for their esthetic and mechanical performance. Acidic challenges in the oral environment can degrade ceramic surfaces, increasing roughness and potentially compromising restoration longevity. This study aimed to evaluate and compare the effect of 4% acetic acid immersion on the surface roughness (Ra) of lithium disilicate glass-ceramic and hybrid ceramic (Vita Enamic) CAD/CAM restorative materials. A total of 40 rectangular specimens (18×15×1 mm) were fabricated, 10 per material per condition. Specimens were polished according to manufacturer protocols and immersed in 4% acetic acid (v/v) at 80∘C for 16 hours, following ISO 6872 standards. Surface roughness was measured using a Roughness Tester (PCE-RT 2000). Data were analyzed using independent t-tests, and effect sizes were calculated (Cohen's d). Both materials exhibited significant increases in surface roughness after acid exposure. Lithium disilicate showed Ra values increasing from 0.0676±0.0187 µm to 0.5129±0.0912 µm (p<0.001, d=4.79). The hybrid ceramic exhibited a larger increase, from 0.2063±0.0568 µm to 1.4409±0.4951 µm (p<0.001, d=2.48). The hybrid material was therefore more susceptible to acid-induced degradation than lithium disilicate. Immersion in 4% acetic acid significantly deteriorates the surface of both lithium disilicate and hybrid ceramic, with hybrid ceramic showing greater roughness changes. Lithium disilicate may be preferred for patients at high risk of acidic challenges. These findings emphasize the importance of material selection and surface management to optimize restoration longevity.
***Keywords.** Lithium Disilicate, Hybrid Ceramic, CAD/CAM, Surface Roughness, Acidic Degradation.*

***Received**: 07/10/25*
***Accepted**: 06/12/25*
***Published**: 11/12/25*

Introduction

All-ceramic restorations fabricated via CAD/CAM technologies have gained widespread acceptance in modern prosthodontics owing to their favorable esthetic properties, biocompatibility, and potential for durable performance. However, the long-term success of these restorations depends not only on their initial mechanical and optical qualities but also on their resistance to chemical degradation in the oral environment, which may include exposure to acidic agents such as dietary acids, gastric reflux, or chemical cleaning solutions. Previous *in vitro* studies have demonstrated that acidic media can adversely affect the surface integrity of dental ceramics—leading to increased surface roughness, microstructural deterioration, and potential weakening of material properties [1–3]. Such degradation may compromise not only the esthetic appearance (through increased surface roughness and potential staining or biofilm accumulation), but also the mechanical longevity and bonding stability of the restorations.

Among all-ceramic materials, glass-ceramics based on lithium disilicate have been widely used because of their excellent esthetics and acceptable mechanical behavior. Yet, even lithium disilicate appears vulnerable to acid-induced surface changes: etching or immersion in acidic solutions has been shown to increase surface roughness significantly [2, 4]. Moreover, comparative studies suggest that the degree of acid-induced degradation may differ substantially between different ceramic materials (e.g., conventional glass-ceramic vs. polymer-infiltrated or hybrid ceramics) and depends on the nature of the acidic challenge, exposure time, temperature, and microstructural composition of the ceramic [2,3,6].

Given the growing popularity of hybrid ceramics (polymer-infiltrated or resin-ceramic materials) for CAD/CAM restorations—combining ceramic and resin phases in a network structure—there is a compelling need to evaluate how these newer materials respond to acidic environments compared with traditional glass-ceramics. Differences in composition and structure may result in markedly different behavior upon acid exposure, perhaps rendering hybrid ceramics more susceptible to surface degradation, roughness increase, or other deteriorations affecting their long-term performance [5,6]. Therefore, the present study aims to investigate and compare the effect of immersion in 4% acetic acid (at elevated temperature) on the surface roughness of two CAD/CAM restorative materials: lithium disilicate glass–ceramic and a hybrid ceramic. By analyzing the changes in surface roughness (Ra) before and after exposure, this research intends to provide

Khalij Libya Journal of Dental and Medical Research. 2025;9(2):308-311
https://doi.org/10.47705/kjdmr.259225
eISSN:*2708-888X*

insight into the durability of these materials under acidic challenge—a factor relevant to their selection for long-lasting aesthetic restorations in patients with high risk of erosive or acidic conditions.

Materials and Methods

Materials and Sample Preparation

This in vitro study evaluated two CAD/CAM restorative materials: Lithium disilicate glass-ceramic (IPS e.max CAD, Ivoclar Vivadent, Schaan, Liechtenstein) and Hybrid ceramic (Vita Enamic, Vita Zahnfabrik, Bad Säckingen, Germany). A total of 40 rectangular specimens were fabricated, with 10 specimens per material group for each condition (control and acid exposure). Each specimen was cut from the respective CAD/CAM blocks using a Hypiont water jet cutting machine (Japan) to dimensions of 18×15×1 mm. All specimens were polished according to the manufacturers' protocols using diamond finishing burs and specific polishing kits. The polished specimens were then ultrasonically cleaned in distilled water for 10 minutes.

Acid Exposure Protocol

For the acid exposure test, each specimen was immersed in a 4% acetic acid solution (v/v) in individual glass bottles. The bottles were maintained at 80∘°C for 16 hours, following ISO 6872 standards for hydrolytic resistance of dental ceramics [2, 3]. Control specimens were stored in distilled water at room temperature for the same duration. After the immersion period, all specimens were rinsed with distilled water and gently dried with soft tissue prior to surface roughness measurement.

Roughness Testing and Statistical Analysis

Surface roughness (Ra) of all specimens was measured using a Roughness Tester PCE-RT 2000 (PCE Instruments, Germany). Three measurements were taken at different locations on each specimen, and the mean Ra value was calculated for each.

Statistical analysis was conducted using SPSS software version 26 (IBM Corp., Armonk, NY, USA). Data were summarized as mean ± standard deviation (SD). Intergroup comparisons between control and acid-exposed specimens (within each material group) were performed using an independent t-test. Significance was set at $p<0.05$. Cohen's d was calculated to determine the effect size, and 95% confidence intervals (CI) were reported.

Results

A total of 20 specimens were evaluated for each material, with 10 specimens per condition (control and acid-exposed). Surface roughness (Ra) measurements were recorded before and after immersion in 4% acetic acid.

The lithium disilicate group demonstrated a significant increase in surface roughness following exposure to acetic acid (Table 1). The mean Ra value increased from 0.0676±0.0187 µm in the control condition to 0.5129±0.0912 µm after acid immersion. An independent t-test revealed a statistically significant difference between control and acid-exposed specimens ($t=-15.13$, $p<0.001$). The calculated effect size indicated a very large effect (Cohen's d=4.79).

Table 1. Surface roughness (Ra) of lithium disilicate specimens before and after 4% acetic acid immersion

Condition	Mean (Ra, µm)	SD	t-value	p-value
Control	0.0676	0.0187	−15.13	< 0.001
Acetic Acid 4%	0.5129	0.0912		

Hybrid ceramic specimens also showed a marked increase in surface roughness after acid exposure (Table 2). Control samples had a mean Ra of 0.2063±0.0568 µm, which increased to 1.4409±0.4951 µm following immersion in 4% acetic acid. Independent t-test analysis confirmed a statistically significant difference ($t=-7.83$, $p<0.001$). The effect size was large (Cohen's d=2.48). Both materials experienced significant deterioration in surface texture after exposure to acetic acid. However, the hybrid ceramic exhibited a greater magnitude of increase in surface roughness, as demonstrated by the significantly higher final mean Ra value and larger confidence interval for the mean difference (−1.583 to −0.886 µm for hybrid vs. −0.468 to −0.388 µm for lithium disilicate). This suggests that the hybrid material is substantially less resistant to the specific acidic challenge used.

https://doi.org/10.47705/kjdmr.259225
eISSN:2708-888X

Table 2. Surface roughness (Ra) of hybrid ceramic specimens before and after 4% acetic acid immersion

Condition	Mean (Ra, μm)	SD	t-value	p-value
Control	0.2063	0.0568	−7.83	< 0.001
Acetic Acid 4%	1.4409	0.4951		

Discussion

This *in vitro* study demonstrated that immersion of CAD/CAM restorative materials in 4% acetic acid at elevated temperature led to a significant increase in surface roughness (Ra) for both the lithium disilicate glass-ceramic and the hybrid ceramic (Vita Enamic), with the hybrid ceramic showing a substantially greater roughness change. These findings have important implications for the long-term performance and clinical longevity of ceramic restorations in acidic oral environments.

The increase in roughness observed here aligns with previous reports on acid-induced degradation of dental ceramics, where studies using acidic agents (including 4% acetic acid) reported significant surface deterioration [7]. In the present study, the hybrid ceramic (polymer-infiltrated network) exhibited more pronounced surface degradation than the lithium disilicate. This may reflect the relative vulnerability of the polymeric phase and the interface within the hybrid network to chemical attack, compared with the more stable crystalline glass-ceramic matrix in lithium disilicate. The acidic solution likely caused the dissolution of the glass matrix and/or hydrolytic degradation of the organic polymer component in the hybrid material, leading to the observed increase in surface irregularities [5, 6].

Moreover, some investigations that used different acidic conditions (e.g., simulated gastric acid, low-pH beverages) observed that ceramic surface roughness, microhardness, and microstructure changed after acid exposure — although the extent of change depended on material composition, acid concentration, exposure time, and surface treatment (polished vs glazed) [8–10]. These variables may explain differences among studies and underscore the need for standardized testing protocols when evaluating the acid resistance of restorative materials

The current results, together with existing evidence, suggest that hybrid ceramics may be less appropriate in patients with a high risk of acidic challenges (e.g., patients with gastro-esophageal reflux disease, high acidic diet, or bulimia). The markedly increased roughness after acid exposure could predispose to enhanced plaque accumulation, staining, or deterioration of marginal integrity—potentially compromising the longevity of restorations. On the other hand, despite the roughness increase in the lithium disilicate group, the magnitude was lower than for hybrid ceramic—supporting the continued use of lithium disilicate glass-ceramic for aesthetic CAD/CAM restorations when acid exposure is a concern. Nonetheless, clinicians should be aware that even lithium disilicate is not immune to acidic degradation under severe conditions [4], especially when initial smoothness deteriorates over time.

Limitations of the present study should be acknowledged. First, the *in vitro* conditions (acid concentration, temperature, immersion time) may not fully replicate the dynamic oral environment. Second, only surface roughness (Ra) was evaluated; other important parameters such as microhardness, flexural strength, color stability, and microstructural changes (e.g., via SEM) were not assessed. Finally, the sample size per group was relatively small; larger-scale studies (with different acid types, pH values, and aging protocols) are needed to better simulate clinical scenarios [11].

Conclusion

Within the constraints of this in vitro investigation, several conclusions may be drawn. Immersion in 4% acetic acid resulted in a significant increase in surface roughness for both lithium disilicate glass-ceramic and the hybrid ceramic material (Vita Enamic) used in CAD/CAM restorations. The hybrid ceramic demonstrated a substantially greater increase in roughness than lithium disilicate, suggesting a lower resistance to acidic degradation. From a clinical perspective, lithium disilicate may therefore be the more suitable option for patients exposed to highly acidic oral conditions, although both materials remain vulnerable to deterioration under prolonged or intense acid exposure. Overall, the findings highlight the need for judicious selection of restorative materials, the application of appropriate surface treatments, and thorough patient education regarding dietary habits and erosive risk factors to enhance the durability and esthetic stability of ceramic restorations.

Conflict of interest. Nil

References

1. Milleding P, Haraldsson C, Karlsson S. Ion leaching from dental ceramics during static in vitro corrosion testing. J Biomed Mater Res. 2002;61(4):541–50.

2. Anusavice KJ, Zhang NZ. Chemical durability of Dicor and lithia-based glass-ceramics. Dent Mater. 1997;13(1):13–9.
3. Kukiattrakoon B, Hengtrakool C, Kedjarune-Leggat U. Chemical durability and microhardness of dental ceramics immersed in acidic agents. Acta Odontol Scand. 2010;68(1):1–10.
4. Alrefae S, Sunarintyas S, Widowati W. Lithium disilicate glass-ceramic surface appearance after acid surface treatment. Indones J Dent Res. 2021;7(2):85–92.
5. Hussein MG. Effect of corrosion and finishing technique on micro-hardness and translucency of dental ceramics. Egypt Dent J. 2025;71(1):123–32.
6. Elsherbini A, Fathy SM, Al-Zordk W, Özcan M, Sakrana AA. Mechanical performance and surface roughness of lithium disilicate and zirconia-reinforced lithium silicate ceramics before and after exposure to acidic challenge. Dent J (Basel). 2025;13(3):117.
7. Wagner M, et al. Effect of acidic agents on surface roughness of dental ceramics. J Prosthet Dent. 2009;122(6):567.e1–8.
8. Ahmed MM, Osama et al. Effect of simulated gastric acid on surface roughness of different types of dental ceramics. Egypt Dent J. 2021;67(1):711–6.
9. Influence of acidic solutions on surface roughness of polished and glazed CAD-CAM restorative materials. Head Face Med. 2025.
10. Palla ES, Dalla AA, Kontonasaki E, Koidis P. Surface degradation of CAD/CAM resin-based composites and lithium disilicate after exposure to low-pH beverages: a systematic review and meta-analysis. J Esthet Restor Dent. 2023;35(4):1126–40.
11. Effects of gastric acid on surface roughness, microhardness, fracture strength, and color change of dental ceramics: a systematic review of in vitro studies. Int J Dent. 2025.