Original Article

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# Impact of Erosive Media on Hybrid Ceramic Occlusal Veneers

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## Abstract:

**Objectives:** This in-vitro study investigated the effect of hybrid ceramic material type and erosive media on the fracture resistance and failure mode of occlusal veneer restorations.

**Methods:** Forty-eight natural mandibular first molars received occlusal veneer restorations (1.0 mm thickness) and were randomly divided into two groups (n = 24) according to the CAD/CAM hybrid ceramic material: SHOFU Block and VITA ENAMIC. Each group was further subdivided into three subgroups (n = 8) based on the erosive medium used for immersion: artificial saliva, simulated gastric hydrochloric acid, and Red Bull energy drink. Veneers were etched with 9.5% hydrofluoric acid, silanated, and adhesively luted to their corresponding prepared teeth using dual-cure resin cement. After 7 days of immersion in each medium at 37 °C with daily renewal, specimens were subjected to fracture testing in a universal testing machine. Failure modes were evaluated using a stereomicroscope. All data were recorded, tabulated, and statistically analyzed. **Results:** A statistically significant difference in fracture resistance was found for SHOFU Block immersed in artificial saliva (3853.45 ± 588.77 N; $P< 0.05$). No statistically significant differences were detected in the failure modes among all tested groups ($P> 0.05$). **Conclusions:** The type of hybrid ceramic material influences the fracture resistance of occlusal veneer restorations following erosive aging, but not the mode of failure.

**Keywords:** Occlusal veneers; CAD/CAM; Hybrid ceramics; Erosive media; Fracture resistance

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## Introduction:

Tooth wear, characterized by the progressive and irreversible loss of dental hard tissues, has emerged as a major clinical concern worldwide due to the rising prevalence of erosive tooth wear.[1] This condition results specifically from the chemical dissolution of enamel and dentin by acids that are non-bacterial in origin. These acids may arise from intrinsic sources, such as gastric acid exposure in gastroesophageal reflux disease or recurrent vomiting, or from extrinsic sources, mainly frequent consumption of acidic foods and beverages like carbonated soft drinks, fruit juices, and citrus fruits.[2] Epidemiological data consistently report a growing prevalence of dental erosion among adolescents and adults, increasing the demand for effective, evidence-based management strategies and durable restorative solutions.[3-5]

The etiology of tooth wear is multifactorial, involving a complex interplay of chemical, mechanical, and biological factors. Acidic challenges lower the pH at the tooth surface, initiating demineralization and softening of enamel and dentin. This renders teeth more vulnerable to mechanical wear from mastication, tooth brushing, and parafunctional habits.[6,7] Both intrinsic gastric acids and extrinsic dietary acids contribute substantially to the condition's pathogenesis.[8,9] Additionally, lifestyle factors such as frequent consumption of soft drinks and energy drinks and systemic conditions that reduce salivary flow and buffering capacity exacerbate erosive tooth wear.[10]

The restorative management of teeth affected by erosive wear has evolved significantly, with an emphasis on minimally invasive approaches that preserve the remaining healthy tooth structure.[11-13] Among the emerging restorative modalities, hybrid ceramic occlusal veneers fabricated using computer-aided design and computer-aided manufacturing (CAD/CAM) technologies have attracted significant attention. Hybrid ceramics, composed of an interpenetrating network of ceramic and polymer phases, exhibit mechanical properties that closely mimic natural tooth tissues, including high flexural strength, enhanced fracture toughness, and favorable elasticity.[14,15] These materials allow for the fabrication of thin, durable restorations with minimal tooth preparation, aligning with modern principles of conservative dentistry.[16]

Despite their material advantages, the long-term performance of hybrid ceramic restorations under erosive challenges remains inadequately understood. Exposure to erosive media such as simulated gastric acid or acidic beverages has been reported to negatively impact the surface integrity and mechanical properties of these materials, particularly their fracture resistance.[17,18] Fracture is recognized as a leading mode of failure in ceramic restorations and poses a significant clinical concern. Failure may occur as microcrack propagation within the material or as catastrophic fractures involving both the restoration and the supporting tooth structure.[19] These failure modes are influenced by factors such as the ceramic composition, the nature and intensity of erosive exposure, and intraoral biomechanical stresses during function and parafunction.[20]

Given the increasing prevalence of erosive tooth wear and the expanding clinical application of CAD/CAM hybrid ceramic occlusal veneers, it is essential to evaluate the effects of erosive environments on their fracture resistance and failure patterns. Such evidence is critical for guiding material selection, optimizing clinical protocols, and improving long-term treatment outcomes in patients affected by erosive tooth wear.

Therefore, the aim of this in-vitro study was to systematically investigate the mechanical performance of hybrid ceramic occlusal veneers subjected to simulated erosive conditions, with particular focus on fracture resistance and failure modes.

The null hypotheses of the study were that:

1. The type of hybrid ceramic restorative material would not significantly affect the fracture resistance or failure mode.
2. The type of erosive medium would not significantly affect the fracture resistance or failure mode.

## 2. MATERIALS AND METHODS:

### 2.1. Ethical approval

Prior to the commencement of the study, the research protocol was reviewed and approved by the Institutional Ethical Committee of Mansoura University, Faculty of Dentistry with code number (A0204023FP).

### 2.2. Specimen preparation

Forty-eight freshly extracted sound human mandibular first molars were collected from the Oral and Maxillofacial Surgery Department, Faculty of dentistry, Mansoura University. Teeth were extracted for periodontal reasons. Immediately after extraction, teeth were cleaned of soft tissue remnants, calculus, and debris using an ultrasonic scalar (UDS-K, Guilin Woodpecker Medical Instrument Co., China), disinfected with 5.25% sodium hypochlorite (Clorox Bleach, Clorox Co., Cairo, Egypt), and stored in distilled water at room temperature. The storage water was replaced weekly to prevent bacterial contamination.

Teeth were examined under ×4 magnification loupes (Ergovision ×4.0, Ergovision Loupes, China)to exclude specimens with cracks, caries, restorations, or structural defects. Dimensions were measured using a digital caliper (150 mm/6 in, American Spares, USA) to ensure standardization. Teeth included measured 11 ± 1 mm mesio-distally at the cemento-enamel junction (CEJ), 10 ± 1 mm bucco-lingually (at greatest convexity), and approximately 5.5 mm occluso-cervically.[21] Specimens with significant crown or root morphological discrepancies were excluded. Selected teeth were stored in distilled water at 37°C until use.

Each tooth was embedded vertically in epoxy resin (Kemapoxy 150, Chemicals for Modern Building International, CMB, Giza, Egypt) within a cylindrical plastic ring (2 mm height, 2.5 mm diameter). A custom centralizing device ensured the long axis of the tooth was aligned parallel to the resin block's axis (Figure 1). The CEJ was positioned 2 mm above the resin surface and teeth were held in place until the resin fully polymerized.

**Figure 1:** Extracted tooth mounted in a custom jig for standardized positioning before embedding in epoxy resin mold.

Custom putty indices were fabricated pre-preparation using hydrophilic addition silicone impression material (Presigum, President Dental, Germany). A constant vertical load of ~6 N was applied during setting by a custom loading device to ensure uniform impression thickness. Two sectioned indices (mesio-distal and bucco-lingual) were used to guide and verify occlusal reduction.[22]

Occlusal preparations were standardized and performed using a surveyor milling machine (Marathon 103, Marathon, China) with a low-speed hand piece (Strong Traus AT-II, Saeshin Precision Co., Korea) mounted at 150° angulations. Depth orientation holes of 1 mm were made at cusp tips and fossae using tapered diamond burs (TR-24, MANI Inc., Japan) and confirmed with a periodontal probe (Figure2). Enamel was reduced uniformly by 1 mm following occlusal anatomy, verified against the putty indices. An additional 1 mm depth reduction into dentin was then performed. Preparations were confined to the occlusal surface with a straight finish line and no axial reduction, per manufacturer guidelines (Figure 3).[23]

**Figure 2:** Tooth marked for occlusal veneer preparation with 1 mm depth orientation holes at cusp tips and fossae using a tapered diamond bur.

**Figure 3:** Occlusal view of occlusal veneer preparation design.

### 2.3. Restoration fabrication

Forty-eight mandibular molars were randomly assigned into two groups (n=24) based on the hybrid ceramic (HC) material used for occlusal veneers: Group S, SHOFU Block resin nano-ceramic (SHOFU Inc., Japan), and Group V, VITA ENAMIC polymer-infiltrated ceramic network (VITA Zahnfabrik, Germany). Each group was further subdivided into three subgroups (n=8) according to the erosive medium used for specimen immersion: artificial saliva (A), simulated gastric hydrochloric acid (HCl) (H), and Red Bull energy drink (R).

Occlusal veneers were fabricated using a CAD/CAM system according to manufacturer's instructions. Following tooth preparation, each specimen was scanned digitally using a laboratory 3D scanner (Identica Hybrid, MEDIT Corp., Seoul, Korea). Surface morphology data were acquired with the manufacturer's software (Collab 2017, MEDIT Corp.). The corresponding occlusal veneer restorations were virtually designed using exocad Chairside CAD software (version 2.2 Valletta, exocad GmbH, Germany) by defining the restoration type as an inlay/ onlay for mandibular first molars and selecting the respective HC materials.

Margins were automatically detected and manually refined as necessary. Cement space was set at 50 µm with a 1 mm margin offset. Restoration thickness was digitally adjusted to approximately 1 mm, following occlusal morphology, and verified using sectional views and caliper tools provided by the software. Virtual smoothing refined the external contours and eliminated sharp edges.

Designed restorations were sent to a 5-axis milling machine (CORITEC 250i, imes-icore GmbH, Germany). Each veneer was milled from its respective HC block using diamond grinding tools suitable for the material, under wet milling conditions. Post-milling, sprue attachments were removed using tapered diamond burs (847G, Ivoclar Vivadent Ltd., New Zealand). Each veneer was visually inspected under magnification for defects and trial-fitted on its prepared tooth to verify adaptation.

Polishing followed manufacturer protocols using dedicated polishing kits. SHOFU Block veneers were polished with SHOFU One Gloss and Super-Snap kits (SHOFU Inc., Kyoto, Japan), employing a two-step mechanical polishing method with initial surface refinement and final high-gloss polishing at low speed and pressure. VITA ENAMIC veneers were polished using the VITA ENAMIC Polishing Set (VITA Zahnfabrik, Germany) through a similar two-step process focusing on delicate finishing and final lustrous polishing. Polished veneers were inspected microscopically to ensure the absence of surface defects and a uniform glossy finish.

### 2.4. Cementation procedure

All occlusal veneers were cemented following the manufacturers' instructions using a standardized protocol. A custom cementation device with a rubberized head mimicking the occlusal morphology and a Teflon base holder was used to ensure uniform seating pressure by applying a static load of 1 kg (approximately 10 N) vertically during cementation.

The fitting surfaces of all veneers (SHOFU Block and VITA ENAMIC) were etched with 9% buffered hydrofluoric acid gel

(WALDENT Chatterpur., New-Delhi, India) for 20 seconds, rinsed, and air-dried until a frosted appearance was observed. A silane coupling agent (BISCO porcelain primer, BISCO Inc., USA) was then applied for 30 seconds and gently air-dried.

Prepared tooth surfaces were cleaned, and the enamel margins were etched with 37% phosphoric acid (ETCH Plus, Dental plus Co, Egypt) for 30 seconds, rinsed, and lightly air-dried. A universal adhesive (All-Bond Universal, BISCO Inc., USA)was applied in two coats with scrubbing for 10–15 seconds each, followed by air evaporation and 10 seconds of light curing.

Dual-cure adhesive resin cement (DUO-LINK UNIVERSAL, BISCO Inc., IL, USA) was dispensed onto the veneers and seated onto the prepared teeth using the cementation device, applying a 10 N load. Excess cement was removed after tack-curing each margin quadrant for 2–3 seconds, followed by full light-curing from all aspects for 40 seconds using a high-intensity LED curing unit (Elipar 2500, 3M ESPE, USA)with a peak output of 450 mW/cm².Final finishing and polishing of margins were performed with a polishing kit as per manufacturer guidelines. Cemented specimens were stored in distilled water at 37°C until further testing.

**2.5. Artificial aging**

Specimens from each main group (Group S and Group V) were immersed in their respective erosive media at 37°C in an incubator for 7 days. Three types of erosive media were used in this study such as: artificial saliva, simulated gastric hydrochloric acid (HCl), and Red Bull energy drink. The media were refreshed every 24 hours to prevent bacterial growth.[24,25] Following immersion, specimen surfaces were rinsed under running water, ultrasonically cleaned in distilled water, and air-dried before further testing.

**2.6. Fracture resistance testing**

All specimens were tested under identical conditions to ensure standardization across groups. Each specimen was tested individually using a universal testing machine (Instron Model 3345, Instron Corp., USA) equipped with a 5 kN load cell and operated via BlueHill 3 software. Specimens were secured with mounting screws, and a 0.6 mm thick tin foil was placed between the occlusal surface and a 6 mm diameter hemispherical steel loading rod to ensure uniform force distribution. A compressive load was applied vertically along the long axis at a crosshead speed of 2.0 mm/min until fracture occurred (Figure

4). The maximum load at failure was recorded in Newtons (N).

**Figure 4:** Specimen fixed in Universal testing machine for fracture load testing.

### 2.7. Failure mode analysis

After fracture testing, all specimens were retrieved and examined under a stereomicroscope at ×20 magnification (Figure 5). Failure modes were classified into four categories: Class I, extensive crack propagation within the restoration; Class II, complete fracture of the restoration only; Class III, adhesive failure at the restoration-tooth interface; and Class IV, longitudinal fracture involving both restoration and tooth (Figure 6).[23]

**Figure 5:** Fractured specimen after static load testing, showing a Class IV longitudinal fracture involving both the restoration and tooth under a stereomicroscope.

**Figure 6:** Occlusal view of a specimen from the SA subgroup showing a Class IV fracture.

## 3. RESULTS:

Data were analyzed using IBM SPSS Statistics version 23.0 (SPSS Inc., Chicago, IL, USA). Quantitative data were presented as mean ± standard deviation (SD), median, minimum, and maximum values. Qualitative data were expressed as frequencies and percentages.

### 3.1. Fracture resistance results

The SHOFU Block group exhibited significantly higher mean fracture resistance (3329.89 ± 607.23 N) than the

VITA ENAMIC group (2685.77 ± 609.86 N; $p = 0.001$) (Table 1).

Within the SHOFU group, specimens immersed in artificial saliva (SA subgroup) showed significantly greater fracture resistance (3853.45 ± 588.77 N) compared to those immersed in simulated gastric HCl (3090.53 ± 527.01 N) or Red Bull energy drink (3045.69 ± 340.74 N) ($p = 0.006$) (Table 2). In contrast, the VITA ENAMIC group showed no significant differences in fracture resistance across the three media: artificial saliva (2597.11 ± 439.72 N), gastric HCl (2703.76 ± 715.66 N), and Red Bull (2756.43 ± 708.13 N) ($p = 0.878$).

When comparing both materials within each erosive medium, SHOFU demonstrated significantly higher fracture resistance than VITA ENAMIC in artificial saliva ($p = 0.001$). However, no significant differences were noted in gastric HCl ($p = 0.239$) or Red Bull ($p = 0.315$).

Further comparisons revealed that the SHOFU subgroup in artificial saliva had significantly higher fracture resistance than the VITA ENAMIC subgroups immersed in gastric HCl ($p = 0.003$) and Red Bull ($p = 0.005$). However, no significant differences were found when comparing SHOFU specimens in gastric HCl or Red Bull to VITA ENAMIC specimens in any erosive medium ($p > 0.05$).

In summary, immersion in artificial saliva favored greater fracture resistance in the SHOFU group compared to both erosive media and to VITA ENAMIC. Exposure to erosive conditions (gastric HCl and Red Bull) led to a reduction in fracture resistance, which was more pronounced in the SHOFU group than in VITA ENAMIC.

**3.2. Failure mode analysis**

Failure modes were evaluated using a stereomicroscope and classified into four categories: Class I, extensive crack propagation within the restoration; Class II, complete fracture of the restoration only; Class III, adhesive failure at the restoration–tooth interface; and Class IV, longitudinal fracture involving both the restoration and the tooth.

No statistically significant difference was found in the distribution of failure modes between the SHOFU and VITA ENAMIC groups ($p = 0.489$) (Table 3). Similarly, no significant differences were observed within each group when comparing different erosive media (SHOFU: $p = 0.267$; VITA ENAMIC: $p = 0.714$).

Comparison of the two materials within each erosive medium also showed no significant differences as artificial saliva (p

= 0.590), simulated gastric HCl (p = 0.205), and Red Bull (p = 0.519). Further subgroup comparisons between SHOFU and VITA ENAMIC specimens under different erosive conditions revealed no significant differences in failure mode distribution (p-values ranged from 0.467 to 0.590). These results suggest that neither the type of hybrid ceramic material nor the erosive medium significantly influenced the failure mode after fracture testing.

**Table 1: Descriptive statistics of fracture resistance test between study groups**

| | Group S (SHOFU) (n=24) | Group V (VITA ENAMIC) (n=24) | Testof Significance | P value |
|---|---|---|---|---|
| Fracture resistance Test | 3329.89±607.233<br>3390.0 (2415-5159) | 2685.77±609.858<br>2426.42 (1899-3784) | T=3.667 | 0.001** |

Data are expressed as mean±SD, median (Min-Max), T: Independent T test, **: highly significant at P<0.01.

**Table 2: Descriptive statistics of fracture resistance test in the SHOFU group versus different erosive media**

| SHOFU group | Group SA Artificial saliva (n=8) | Group SH Simulated gastric HCL (n=8) | Group SR Red Bull (n=8) | Test of Significance | P value |
|---|---|---|---|---|---|
| Fracture resistance Test | 3853.45±588.772 3632.08 (3409-5159) | 3090.53±527.01 3191.85 (2415-3697) | 3045.69±340.74 3191.85 (2415-3697) | F=6.679 | 0.006** |
| Post-hoc test pairwise comparison | A.S versus G: T= 2.731, P1=0.016*<br>A.S versus Red: T= 3.359, P2=0.005**<br>G versus Red: T= 0.202, P3=0.843 | | | | |

Data are expressed as mean±SD, median (Min-Max), F: Analysis of variance (ANOVA) test, **: highly significant at P<0.01, P: p value of ANOVA test, Post Hoc
Pair wise comparison:

P1: p value between group SA versus SH.
P2: p value between group SA versus SR.
P3: p value between SH versus SR.

**Table 3:** Descriptive statistics of failure mode between the two study groups

| | Group S (SHOFU) (n=24) | Group V (VITAENAMIC) (n=24) | Test of Significance | P value |
|---|---|---|---|---|
| Mode of failure | | | | |
| Class I | 0 (0%) | 1 (4.2%) | | |
| Class II | 4 (16.7%) | 6 (25%) | FEX= 1.589 | 0.489 |
| Class IV | 20 (83.3%) | 17 (77.1%) | | |

Data are expressed as mean±SD, median (Min-Max), frequency (percentage), T: Independent T test, FEX: Fisher Exact test, **: highly significant at P<0.01. **Class I**: Extensive crack formation within the restoration, **Class II**: Fracture of the restoration only, **Class IV**: Longitudinal fracture of the restoration and tooth.

## 4. DISCUSSION:

The main goal of this study was to evaluate the influence of hybrid ceramic restorative material and exposure to different erosive media on the fracture resistance and failure modes of occlusal veneer restorations. According to the present findings, the null hypotheses were partially rejected: both the type of hybrid ceramic and the erosive medium significantly influenced fracture resistance, whereas no significant differences were observed in the failure mode patterns among the tested groups.

This study uniquely investigated the combined effects of different erosive mediaon the fracture resistance and failure modes of CAD/CAM-fabricated hybrid ceramic occlusal veneers on natural mandibular first molars. Previous Pub Med studies mostly focused on isolated materials or single aging methods, often with artificial substrates. However, this study's simultaneous evaluation of multiple clinically relevant acidic exposures with standardized veneer preparation and adhesive protocols has not been reported. Alqahtani et al. (2023)[26] examined acid effects on hybrid ceramics but did not assess multiple erosive media impacts on both fracture resistance and failure modes in natural teeth.

In selecting the restorative materials, SHOFU Block and VITA ENAMIC were chosen as representative examples of commonly used hybrid ceramics exhibiting distinct microstructural characteristics.[24] SHOFU Block is characterized by its dense ceramic network, whereas VITA ENAMIC incorporates a polymer-infiltrated ceramic matrix. According to Müller and Schmidt (2023),[27] the dual-network architecture of VITA ENAMIC may confer enhanced resistance to crack propagation and acid-induced degradation. This property positions VITA ENAMIC as a particularly suitable restorative material for patients exposed to elevated erosive challenges.

The erosive challenge in this study was modeled using three immersion media: artificial saliva, simulated gastric hydrochloric acid, and Red Bull energy drink. These media were selected to represent common intrinsic and extrinsic acid exposures encountered clinically, as supported by Patel and Lee (2023)[25] and Silva et al. (2024).[28] Simulated gastric acid (pH 1.2) mimics intrinsic acid exposure associated with conditions such as gastroesophageal reflux disease (GERD), whereas energy drinks (pH 3.5) reflect the increasing influence of dietary acids, particularly prevalent among younger populations.[29]

Occlusal veneer preparations in this study were standardized to a uniform thickness of 1.0 mm, incorporating butt joint margins and rounded internal angles. This preparation design aligns with contemporary principles of minimally invasive restorative dentistry, which prioritize maximal preservation of healthy tooth structure while ensuring sufficient material thickness to achieve optimal mechanical strength and long-term durability. The use of butt joint margins facilitates a stable and uniform seating of the veneer, enhancing marginal integrity and reducing stress concentrations at the restoration-tooth interface. Rounded internal angles further contribute to improved stress distribution within the restoration and underlying tooth substrate, minimizing the risk of crack initiation and propagation. Conservative preparation geometries are critical for balancing structural preservation with functional performance, ultimately supporting the longevity and clinical success of ceramic-based occlusal veneers in patients.[27]

High-precision CAD/CAM technology was used to fabricate all restorations. This ensured consistent fit and optimal adaptation to tooth surfaces. This digital process reduces human error and variability, enhancing restoration accuracy. As supported by Zafar et al. (2021),[30] such precision provides excellent marginal integrity, which is crucial for esthetics, longevity, and clinical performance by minimizing microleakage, secondary caries, and stress-induced fractures. Therefore, CAD/CAM's precise fit significantly contributes to improved restoration durability and resistance to mechanical failure.

A dual-cure resin cement was used for adhesive luting, following hydrofluoric acid etching and silanization of the internal surfaces. The superior performance of resin cements in bonding to hybrid ceramics has been emphasized by Albelasy and Hamama (2021),[31] who reported their enhanced mechanical properties and effective ability to distribute functional stresses, contributing to improved clinical outcomes.

The immersion protocol entailed seven days of storage at 37°C in the respective media, with daily renewal. This approach is consistent with recent laboratory studies investigating the effects of acid exposure on restorative materials and, while not fully replicating the complexity of the oral environment, provides valuable insight into the initial effects of erosive challenge.[24,25]

The findings of the present study revealed that SHOFU Block consistently demonstrated superior fracture resistance compared to VITA ENAMIC, particularly in neutral artificial saliva, aligning with the hypothesis that ceramic microstructure governs mechanical performance. The enhanced fracture resistance of SHOFU Block is attributable to its polymer-infiltrated ceramic network (PICN) design, which enables more effective stress distribution and crack arresting mechanisms. Such microstructural advantages have been reported previously by Alqahtani et al.(2023)[26]and Rennes et al.(2023),[32]confirming that PICN materials outperform feldspathic-based hybrids under mechanical stress.

Exposure to acidic erosive media significantly compromised SHOFU Block's fracture resistance, emphasizing its polymer phase's vulnerability to acid degradation. This observation was consistent with Alqahtani et al.(2023),[26]who explained acid-induced polymer matrix weakening and surface roughening leading to reduced load-bearing capacity in PICNs. Conversely, VITA ENAMIC's fracture resistance remained remarkably stable across all erosive conditions, suggesting its ceramic-rich matrix confers greater resistance to chemical degradation, as supported by Silva et al.(2024).[33] While this acid resistance is advantageous, contrasting studies such as Elmokadem et al.(2024)[34] have reported no difference in fracture resistance between similar hybrid ceramics after aging, possibly due to varied aging protocols or substrate differences, highlighting the significant impact of experimental conditions on performance outcomes.

Failure mode analysis predominantly showed catastrophic longitudinal fractures involving both veneer and tooth, typical for brittle materials under occlusal loading. This uniform failure pattern across groups suggests similar fracture propagation kinetics despite variable fracture resistance, an outcome consistent with prior research by Alrahlah et al.(2017)[35] and Gresnigt et al.(2011).[36] The presence of less frequent adhesive (restoration-only) and internal crack failures also points to the critical role of adhesive interface integrity and microstructural flaws as initiators of restoration failure. The absence of purely cohesive failures implies that bulk restoration strength was generally maintained, and failure initiation was more dependent on interface degradation and stress concentrations.

Clinically, SHOFU Block's higher strength favors its use in load-bearing restorations but requires caution in erosive environments, while VITA ENAMIC may suit patients with high acid exposure despite lower baseline strength. These results support personalized material selection that balances mechanical demands with a patient's erosive risk.

In conclusion, ceramic microstructure critically influences hybrid ceramic veneer durability post-erosive aging. SHOFU Block offers superior strength but greater acid vulnerability; VITA ENAMIC demonstrates better acid resistance with lower fracture resistance. Failure modes remain consistently catastrophic, guiding clinical material choices and highlighting the need for further in-vivo validation.

The limitations of this in-vitro study might be that more research is needed to validate this testing approach, including assessing higher load magnitudes, increased fatigue cycles, and varied thermal cycling protocols. Additionally, testing different adhesive cements and surface treatments is necessary, as the current aging protocol does not fully replicate the complex oral environment. Future long-term, multifactorial aging studies and clinical trials are essential to better predict hybrid ceramic veneer durability.

## 5. CONCLUSIONS:

Based on the results of this study, the following conclusions can be drawn

1. Hybrid ceramic microstructure critically influences fracture resistance and failure behavior following erosive aging.
2. Material type and erosive challenge did not significantly affect the failure mode.

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