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EVALUATING THE RELATIONSHIP BETWEEN SALIVARY BIOMARKERS AND THE CLINICAL EFFECTIVENESS OF RESTORATIVE DENTAL MATERIALS

Dr. Hina Ashraf[1], Dr. Laiba Khalid[2], Dr. Sana Ikram[3*], Dr. Muhammad Arsalan Raffat[4], Dr. Syeda Faiza Gillani[5], Dr. Ambreen[6]

[1]Assistant Professor Dental Materials, Ayub Medical College, Dental Section, Abbottabad, Pakistan
[2]Resident Oral Biology, KMU, Peshawar, Pakistan.
[3*]Associate Professor Oral Biology, Shahida Islam Dental College, Lodhran, Pakistan
[4]Associate Professor and Head of the Oral Pathology Department, Faculty of Dentistry, Shahida Islam Medical Complex, Lodhran, Punjab
[5]Lecturer, KMU-IDS, Kohat, Pakistan
[6]Demonstrator Oral pathology, KMU-IDS, Kohat, Pakistan

***Corresponding Author:** Dr. Sana Ikram,
*Associate Professor Oral Biology, Shahida Islam Dental College, Lodhran, Pakistan.
Email: drsanaikram@gmail.com

ABSTRACT

Introduction: The pursuit of long-lasting, biocompatible, and clinically successful restorative materials remains a fundamental goal in restorative dentistry.[1] Advances in material sciences have yielded a broad array of dental restoratives ranging from composite resins and glass ionomer cements to high-performance ceramics each designed to restore function and aesthetics while minimizing biological incompatibility

Objective: This study aims to investigate the relationship between salivary biomarkers and the clinical effectiveness of various restorative dental materials. By identifying biochemical markers in saliva associated with inflammation, tissue response, and oral health status, the research seeks to establish a potential correlation with the performance and longevity of dental restorations.

Methods: A cohort of patients receiving restorative treatments using composite resins, glass ionomer cements, and ceramic-based materials were monitored over a 12-month period. Saliva samples were collected at baseline and at regular follow-ups to assess levels of biomarkers such as matrix metalloproteinases (MMPs), C-reactive protein (CRP), interleukins (IL-1β, IL-6), and oxidative stress markers. Clinical evaluations included assessments of marginal integrity, postoperative sensitivity, secondary caries, and restoration failure.

Results: Preliminary findings suggest a significant association between elevated levels of inflammatory biomarkers and reduced clinical success of certain restorative materials, particularly in patients with poor oral hygiene or systemic inflammatory conditions. Ceramic restorations showed the least biomarker-associated degradation, while resin-based composites demonstrated greater variability in outcomes linked to biomarker fluctuations.

Conclusion: Salivary biomarkers may serve as valuable non-invasive indicators for predicting the clinical performance of restorative dental materials. Integration of salivary diagnostics into routine dental practice could enhance material selection and personalized treatment planning, ultimately improving long-term restorative outcomes.

Keywords: Salivary Biomarkers, Clinical Effectiveness, Restorative Dental Materials

INTRODUCTION

The pursuit of long-lasting, biocompatible, and clinically successful restorative materials remains a fundamental goal in restorative dentistry.[1] Advances in material sciences have yielded a broad array of dental restoratives ranging from composite resins and glass ionomer cements to high-performance ceramics each designed to restore function and aesthetics while minimizing biological incompatibility.[2] Despite technological improvements, clinical failures due to secondary caries, marginal leakage, or restoration breakdown remain prevalent, necessitating a deeper understanding of host-related influences on restoration performance. Recent years have seen a paradigm shift in dentistry from merely mechanical repair of tooth structures to a more biologically guided approach.[3] The oral environment is highly dynamic, influenced by local microbial flora, dietary habits, and host immune responses. Saliva, a complex biofluid, plays a central role in maintaining oral homeostasis and is increasingly recognized as a mirror of systemic and local health. It contains a wide spectrum of biomarkers proteins, enzymes, cytokines, and oxidative stress indicators that offer insights into inflammatory states and tissue responses.[4]

Of particular interest in the realm of biomarker research are matrix metalloproteinases (MMPs), notably MMP-8, which have been implicated in the breakdown of dentin and degradation of adhesive interfaces in resin-based restorations. Similarly, pro-inflammatory cytokines such as interleukin-1 beta (IL-1β) and interleukin-6 (IL-6) are known mediators of periodontal inflammation and may influence the surrounding microenvironment of restorative materials.[5] C-reactive protein (CRP), though systemically derived, is detectable in saliva and has shown correlations with both periodontal disease severity and general systemic inflammation. Oxidative stress markers like 8-hydroxydeoxyguanosine (8-OHdG) further reflect the host's oxidative burden, which may negatively affect the biochemical stability of dental materials.[6] While previous studies[5-7] have explored the impact of salivary enzymes on dentin bonding and the degradation of adhesive materials, comprehensive research evaluating multiple biomarkers in clinical settings remains limited. Moreover, most research has focused on isolated laboratory conditions, failing to capture the multifactorial influences present in the oral cavity over time.

In light of this, the present study adopts a longitudinal clinical model to assess the relationship between salivary biomarkers and the clinical effectiveness of restorative materials over a 12-month period. By monitoring biomarker fluctuations in correlation with restoration performance, the study aims to bridge the gap between biochemical diagnostics and material science. Specifically, it investigates whether elevated levels of MMP-8, CRP, IL-1β, IL-6, and oxidative stress markers are associated with higher rates of clinical failure in restorations made from composite resin, glass ionomer cement, and ceramic-based materials. This approach seeks to determine if saliva-based diagnostics can be used as a predictive tool in restorative dentistry, allowing for personalized treatment planning based on a patient's biological risk profile. The overarching goal is to improve the selection and longevity of restorative materials, potentially integrating salivary analysis as a standard pre-treatment assessment in dental practice.

METHODOLOGY

This longitudinal clinical study included 90 patients aged 20–60, each requiring dental restorative treatment. Participants were divided into three equal groups of 30, each receiving restorations with either composite resin, glass ionomer cement (GIC), or ceramic-based materials. Inclusion criteria ensured participants had no systemic diseases or conditions that could affect salivary gland function or immune responses. Standardized operative protocols were followed for cavity preparation and restoration. Clinical evaluations were performed at baseline and at 3, 6, and 12 months post-treatment using the modified United States Public Health Service (USPHS) criteria. Restoration performance was assessed in terms of marginal integrity, secondary caries, postoperative sensitivity, and overall restoration failure.

Saliva samples were collected at each clinical visit. Participants refrained from eating or drinking for at least one hour prior to collection. Samples were centrifuged, stored at –80°C, and analyzed using enzyme-linked immunosorbent assay (ELISA) kits for MMP-8, CRP, IL-1β, IL-6, and 8-OHdG. Statistical analysis was conducted using ANOVA and multiple regression models to evaluate correlations between biomarker levels and clinical outcomes.

RESULTS

Analysis revealed a significant association between elevated biomarker levels and clinical deterioration of certain restorative materials (Table 1).

Table 1. Mean Salivary Biomarker Levels (pg/mL) at Baseline

Biomarker	Composite Group	GIC Group	Ceramic Group
MMP-8	432.1 ± 45.3	410.6 ± 38.2	389.8 ± 30.4
CRP	2.8 ± 0.6	2.4 ± 0.5	2.1 ± 0.4
IL-1β	79.6 ± 12.3	70.2 ± 10.1	65.7 ± 8.9
IL-6	48.3 ± 9.2	44.1 ± 8.4	41.5 ± 7.1
8-OHdG	13.4 ± 3.2	11.6 ± 2.9	9.8 ± 2.4

Composite resin showed the highest failure rate, closely linked to increased MMP-8 and IL-6 levels (Table 2).

Table 2. Restoration Failure Rates at 12 Months

Material	Restoration Failure (%)	Most Common Cause
Composite Resin	26.7%	Marginal breakdown, caries
GIC	13.3%	Surface roughness
Ceramic	6.7%	None significant

DISCUSSION

The present study provides compelling evidence for a biological influence on the clinical performance of restorative dental materials, with salivary biomarkers emerging as potential indicators of restoration prognosis. Composite resins, despite their aesthetic and functional advantages, exhibited the highest failure rates, which were significantly associated with elevated levels of MMP-8 and inflammatory cytokines. These findings align with previous laboratory-based research that documented the enzymatic degradation of resin-dentin bonds in the presence of MMPs and oxidative stress. For example, Poimenidou et al. (2025)[8] emphasized the role of MMPs in collagen degradation at the resin-dentin interface, which may compromise restoration longevity. Similarly, a study by Albagieh et al. (2025)[9] found that saliva from periodontally compromised individuals significantly weakened resin bonds compared to saliva from healthy controls. Compared to composites, ceramic restorations demonstrated superior resistance to salivary biomarker fluctuations. Their inert, non-porous surface likely limits interaction with enzymes and cytokines, supporting the results of Birant et al. (2024)[10], who reported high survival rates of ceramic restorations in patients with high inflammatory burdens. GICs, known for their fluoride-releasing properties and chemical bonding, performed moderately. However, their mechanical limitations made them susceptible to surface wear, especially in high-stress areas. Notably, GICs appeared less affected by elevated IL-1β or oxidative markers, potentially due to their hydrophilic and bioactive nature. These findings are consistent with results from a clinical trial by Hussein et al (2025)[11], which highlighted the stable performance of GICs in patients with varying oral hygiene levels. This study highlights the importance of moving beyond one-size-fits-all restorative strategies. As precision medicine becomes increasingly relevant in dentistry, integrating salivary diagnostics may allow clinicians to anticipate restoration outcomes

and tailor material choice accordingly. For instance, in patients with elevated salivary MMPs or systemic inflammatory markers, clinicians might opt for ceramic restorations over composites to mitigate risk. Nonetheless, limitations exist. The sample size, although sufficient for preliminary analysis, may not account for inter-individual variations due to genetics, diet, and systemic health. Furthermore, while the ELISA method is accurate, salivary biomarker levels can fluctuate due to short-term environmental or emotional stressors. Future studies should include broader populations and explore the effect of salivary modulation (e.g., via anti-inflammatory mouthwashes or dietary changes) on restorative outcomes. Development of rapid, point-of-care salivary tests could further enable real-time risk assessment in dental settings.

CONCLUSION

Salivary biomarkers, especially MMP-8, IL-1β, IL-6, and CRP, show strong correlations with the clinical effectiveness of restorative dental materials. Composite resins are particularly vulnerable to degradation in inflammatory environments, while ceramic restorations exhibit higher resilience. These findings advocate for the integration of salivary diagnostics into clinical decision-making for more personalized and durable dental restorations.

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