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Salivary Biomarkers Today and their Role in Conservative Dentistry - A Review

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INTRODUCTION

Saliva has evolved from being considered a mere digestive fluid to a powerful diagnostic medium. Its rich composition of proteins, enzymes, hormones, DNA, RNA, and microorganisms has led researchers and clinicians to explore its potential as a tool for non-invasive diagnosis[1]. Salivary biomarkers which are specific molecules, indicate physiological or pathological conditions - are now being investigated for their applications in conservative dentistry, a branch that focuses on preserving natural tooth structure through prevention, diagnosis, and minimally invasive treatment[2].

As the burden of dental diseases like caries, pulpitis, and erosion continues to rise, especially in developing countries, early detection becomes paramount. Traditional diagnostic methods such as radiographs or tactile inspection often detect disease at a relatively advanced stage. In contrast, salivary diagnostics can identify subclinical changes, allowing clinicians to intervene before irreversible damage occurs. This paradigm shift from intervention to prevention aligns seamlessly with the philosophy of conservative dentistry.

Composition of Saliva and Diagnostic Relevance

Human saliva is composed of secretions from major salivary glands—parotid, submandibular, and sublingual—as well as minor glands dispersed throughout the oral mucosa. It contains:

- Water (99%)
- Electrolytes (e.g., sodium, potassium, calcium)
- Enzymes (e.g., amylase, peroxidase)
- Immunoglobulins (especially secretory IgA)
- Antimicrobial peptides (e.g., histatins, defensins)
- Mucins
- Metabolic waste
- Microbial by-products

This complex matrix allows saliva to mirror both oral and systemic health conditions. Crucially, because many disease-related molecules can diffuse from blood into saliva, biomarkers relevant to caries activity, periodontal disease, and pulpal inflammation can be reliably detected in salivary samples.

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Salivary Biomarkers Relevant to Conservative Dentistry

Dental Caries Detection

Dental caries is a dynamic biofilm-mediated process where mineral loss outweighs remineralization. The following biomarkers are pivotal:

Streptococcus mutans and Lactobacilli count: These bacteria produce lactic acid from carbohydrate metabolism, directly contributing to enamel demineralization. Their concentration in saliva correlates with caries activity[3].

pH and buffering capacity: Acidic saliva (pH < 5.5) favours demineralization. Saliva's buffering action, mainly via bicarbonate, phosphate, and proteins, plays a protective role.

Salivary urea and ammonia: Elevated levels neutralize acids, potentially reducing caries risk.

Calcium, phosphate, and fluoride levels: These ions are central to remineralization. Salivary tests measuring their concentration can inform preventive strategies.

Matrix metalloproteinases (MMPs): Specifically MMP-8 and MMP-9, which are host-derived enzymes implicated in dentinal collagen degradation during caries progression[4].

Pulpal and Periapical Pathologies

Detecting early pulpal inflammation remains a clinical challenge. Salivary biomarkers offer potential here:

Pro-inflammatory cytokines (e.g., IL-6, IL-8, TNF-α): Elevated levels of these cytokines in saliva can indicate pulpitis or apical periodontitis, even before clinical symptoms manifest[5].

Neuropeptides (e.g., Substance P, CGRP): These markers reflect nociceptive activity and inflammation within the pulp.

Exosomal RNA: These are small extracellular vesicles containing RNA, recently shown to carry specific transcripts linked to pulpal and periodontal inflammation.

Tooth Erosion and Abrasion

Non-carious cervical lesions can be early signs of erosive damage. Salivary parameters influencing this include:

- Acid-neutralising capacity
- Pellicle protein profiles

Carbonic anhydrase VI: This enzyme contributes to maintaining a neutral pH and is considered protective against erosion[6].

Salivary Diagnostics in Clinical Conservative Practice

Risk Assessment and Caries Management by Risk Assessment (CAMBRA)

In risk-based dentistry models like CAMBRA, salivary testing can stratify patients based on microbial load, buffer capacity, and ionic composition. This enables tailored interventions:

- High-risk patients receive fluoride varnishes, chlorhexidine rinses, and dietary counselling.
- Low-risk patients can be managed with routine care and preventive reinforcement.

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Monitoring Therapeutic Outcomes

After fluoride therapy or antimicrobial treatment, salivary testing helps assess the reduction in cariogenic bacterial load and improvement in remineralisation markers. This feedback loop allows dynamic treatment planning, avoiding over treatment.

Early Diagnosis = Minimally Invasive Dentistry

The earlier a lesion is detected, the more likely it can be reversed or halted without drilling. Salivary biomarkers, when integrated with other non-invasive tools like **quantitative light-induced fluorescence (QLF)** or **optical coherence tomography (OCT)**, form a powerful diagnostic alliance.

Advances in Technology: Lab-On-A-Chip and Point-Of-Care Devices

Technological innovations are rapidly improving the feasibility of salivary diagnostics. Microfluidic devices, often referred to as "lab-on-a-chip" systems, allow real-time analysis of multiple biomarkers from a single droplet of saliva. These systems are:

- Portable
- Cost-effective
- Quick (results in minutes)
- Suitable for chair side use

The development of point-of-care salivary biosensors may soon make routine salivary analysis as common as taking a dental history.

LIMITATIONS AND CHALLENGES

Despite immense potential, the use of salivary biomarkers in conservative dentistry faces some hurdles:

Biological variability: Saliva composition varies based on hydration, time of day, medications, and systemic health.

Standardization issues: There is a lack of universally accepted reference values for many salivary markers.

Contamination risks: Saliva is easily contaminated by food, blood, or microbial flora, which can skew results.

Cost and accessibility: While technologies are improving, the widespread clinical use of salivary diagnostics remains limited in low-resource settings[7].

FUTURE DIRECTIONS

To enhance the utility of salivary biomarkers in conservative dentistry:

Longitudinal studies are needed to validate biomarker reliability and establish clinical thresholds.

Integration with artificial intelligence can help analyze complex salivary data sets to predict disease risk accurately.

Personalized dental care using salivary profiles could become the new norm—linking host immune response, microbial factors, and environmental influences into one diagnostic model.

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Education and training must be integrated into dental curricula to equip future dentists with the skills to interpret and utilize salivary diagnostics.

CONCLUSION

The application of salivary biomarkers in conservative dentistry signifies a paradigm shift from reaction to prevention. Through the early detection of caries, pulpal inflammation, and erosive processes, clinicians can initiate minimally invasive strategies that preserve tooth structure and enhance patient outcomes. While challenges remain, ongoing research and technological progress promise to make saliva-based diagnostics an integral part of daily dental practice. Embracing this non-invasive, cost-effective, and patient-friendly approach could very well define the next era of conservative dentistry.

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