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Original Research Article

Salivary albumin as a potential biomarker for dental caries in adult population in Haryana: Evidence from an in vivo study

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Abstract

Introduction: Dental caries remains a prevalent oral health concern, with saliva playing a crucial role in its prevention and progression. Among salivary components, albumin has gained attention as a potential biomarker, prompting this study to explore its correlation with the severity of dental caries.
Aim and Objective: The study investigated the correlation between salivary albumin levels and dental caries in the adult population of Haryana based on Decayed, Missing, and Filled Teeth (DMFT) scores.
Materials and Methods: The study was conducted on sixty adult participants who were divided into 4 groups based on their Decayed, Missing and Filled Teeth scores: Group 1 (DMFT 0, caries-free), Group 2 (DMFT 1-5), Group 3 (DMFT 6-10), and Group 4 (DMFT >10). Standardized procedures were used to obtain unstimulated saliva samples from each participant. Salivary albumin levels were measured using the Agappe albumin kit and the bromocresol green technique. One-way ANOVA and Tukey's post-hoc test were used to statistically analyze the collected data, with a significance threshold of $p < 0.05$.
Results: Salivary albumin levels and DMFT scores were found to be significantly inversely correlated by statistical analysis ($p = 0.001$). The mean salivary albumin levels were highest in Group 1 (0.34 ± 0.08 mg/mL) and progressively decreased across Group 2 (0.33 ± 0.08 mg/mL), Group 3 (0.20 ± 0.11 mg/mL), and Group 4 (0.12 ± 0.04 mg/mL). Post-hoc analysis confirmed significant differences between caries-free individuals and those with high DMFT scores.
Conclusion: The findings of this study suggest that lower salivary albumin levels are associated with increased susceptibility to dental caries.

Keywords: Salivary albumin, Dental caries, DMFT score, Saliva, Oral health, Biomarker.

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1. Introduction

Saliva is a vital biological fluid that plays an essential role in maintaining oral and systemic health. It is composed of various proteins, enzymes, and electrolytes that contribute to its protective functions, including antimicrobial defence, lubrication, and remineralization of enamel.[1] Among these components, salivary albumin has gained attention due to its potential role as a biomarker for oral diseases, particularly dental caries.[2]

Dental caries is a chronic, multifactorial disease resulting from the demineralization of enamel and dentin by acidic byproducts of bacterial metabolism.[3] Factors influencing caries progression include diet, oral hygiene, salivary composition, and genetic predisposition.

Despite growing interest in salivary biomarkers for caries risk assessment, evidence remains inconclusive. Prior studies from regions such as Karnataka and Chennai, report an inverse relationship between salivary albumin levels and caries severity,[4,5] yet systematic reviews highlight methodological heterogeneity and insufficient evidence to definitively establish albumin as a reliable biomarker.[6] Existing research is further limited by small sample sizes, narrow demographic representation, inconsistent saliva collection protocols, and variable caries scoring systems.[1,5] Crucially, data from North Indian populations especially adult cohorts from Haryana are absent. Furthermore, the

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underlying protective mechanisms of albumin in enamel remineralization or biofilm modulation remain poorly understood. Some researchers have proposed that albumin helps prevent demineralisation by forming a protective barrier on enamel surfaces, while others argue that albumin accumulation in carious lesions may hinder remineralisation.[7] Understanding this relationship is crucial for developing non-invasive diagnostic tools and preventive measures for caries management.

This study aims to address these gaps by evaluating salivary albumin levels in unstimulated saliva among adults in Haryana with varying DMFT scores, using a standardized methodology. By examining the variations in salivary albumin concentrations across different caries severity groups, this research seeks to provide valuable insights into the potential role of salivary biomarkers in oral health assessment and disease prevention.

2. Materials and Methods

Ethical clearance was received from the institutional ethical committee for this in-vivo study. The study participants were chosen from among the patients who were referred to the Department of Conservative Dentistry and Endodontics for treatment. The study was registered with Clinical Trial Registry number CTRI/2024/11/077371.

2.1. Inclusion criteria

1. Healthy, compliant and consenting patients who were referred to the Department of Endodontics.
2. Patients having dental caries.
3. Subjects in the age group of 18 to 40 years
4. Patients free from systemic and local disease which affect salivary secretions.

2.2. Exclusion criteria

1. Individuals who have a history of long-term medicine intake, radiation, chemotherapy, diabetes, hypertension, periodontal disease, or systemic disease of key organs were not included.

The sample size was established using the G Power Software (version 3.0.10). The minimal sample size was determined to be 60 patients, with 15 samples in each group, based on the study's computed effect size of 0.319, 5% precision level, 95% confidence level, and 80% power.

This in vivo study was conducted on 60 adult subjects categorized into four groups based on DMFT scores: Group 1 (DMFT 0, caries-free), Group 2 (DMFT 1-5), Group 3 (DMFT 6-10), and Group 4 (DMFT >10). Saliva samples were collected under standardized conditions using the unstimulated drool method. Participants were advised to restrict from eating, drinking, smoking, and brushing, at least one hour prior to saliva collection. After 15 minutes of centrifuging the samples at 3000 rpm, the supernatant was kept at -10°C until it was time for analysis. The agappe albumin kit was used to quantify the amounts of salivary albumin using the bromocresol green method. The samples' absorbance was measured with a spectrophotometer.

2.3. Statistical analysis

SPSS version 21 was used to analyze the findings. The means and standard deviations of descriptive statistics were displayed. Normality was determined using the Shapiro-Wilk test, and then salivary albumin levels were compared between groups using a one-way ANOVA and Tukey's post-hoc test. Statistical significance was defined as a p-value <0.05.

3. Results

The results of this study revealed a statistically significant inverse correlation between salivary albumin levels and dental caries severity, as demonstrated by the one-way ANOVA analysis (**Table 1**, F = 25.437, p = 0.001). The mean salivary albumin levels were found to be the highest in Group 1 (DMFT 0) at 0.34 ± 0.08 mg/mL and gradually declined as the severity of dental caries increased (**Figure 1**). Group 2 (DMFT 1-5) exhibited a mean albumin concentration of 0.33 ± 0.08 mg/mL, while Group 3 (DMFT 6-10) demonstrated a significant reduction to 0.20 ± 0.11 mg/mL. The lowest mean albumin levels were recorded in Group 4 (DMFT >10) at 0.12 ± 0.04 mg/mL. The progressive decrease in salivary albumin levels among the groups indicates that albumin concentration declines as caries severity increases.

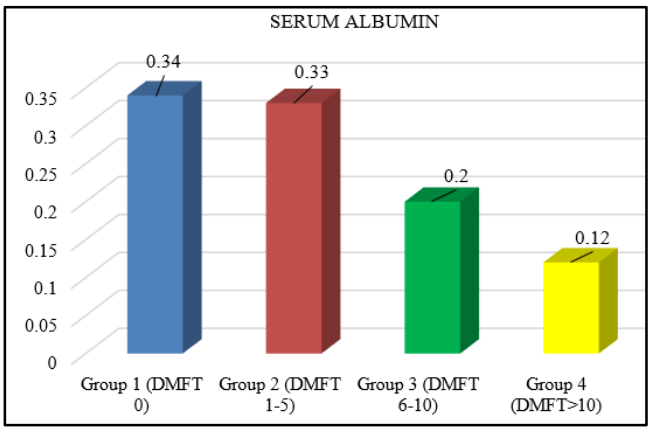

Figure 1: Mean distribution of salivary albumin levels among the four groups

The post-hoc Tukey's pairwise comparison analysis (**Table 2**) further substantiated these findings, revealing significant differences between groups with varying DMFT scores. Group 1 displayed significantly higher albumin levels compared to Groups 3 and 4 (p = 0.001), emphasising the marked reduction in albumin levels as caries severity advances. Similarly, Group 2 exhibited significantly higher albumin concentrations than Groups 3 and 4, indicating that even mild to moderate caries development is associated with a measurable decline in salivary albumin. However, no significant difference was found between Groups 1 and 2 (p = 0.996), suggesting that albumin levels remain relatively

stable in the early stages of caries development before experiencing a sharp decline in individuals with higher DMFT scores.

Additionally, the confidence intervals for mean albumin levels across groups further validate the observed trend. The 95% confidence interval for Group 1 ranged from 0.29 to 0.38 mg/mL, whereas the interval for Group 4 was significantly lower, ranging from 0.10 to 0.14 mg/mL. The substantial variation in albumin levels among the groups highlights its potential role as a biomarker for assessing caries severity. The lowest recorded albumin levels in this study were 0.09 mg/mL in Group 4, while the highest recorded levels reached 0.45 mg/mL in Groups 1 and 2, reinforcing the idea that albumin concentration is influenced by caries progression.

This trend suggests that individuals with more severe dental caries exhibit lower salivary albumin levels.

Table 1: Comparison of mean salivary albumin levels among the four groups

	N	Mean	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Group 1 (DMFT 0)	15	0.34	0.08	0.29	0.38	0.27	0.45
Group 2 (DMFT 1-5)	15	0.33	0.08	0.28	0.37	0.26	0.45
Group 3 (DMFT 6-10)	15	0.20	0.11	0.14	0.26	0.09	0.36
Group 4 (DMFT>10)	15	0.12	0.04	0.10	0.14	0.09	0.18
F value, p value		25.437, 0.001*, sig					

One way anova, level of significance set at $p < 0.05$
Ns: non-significant, sig: significant

Table 2: Mean difference of salivary albumin levels among the four groups

(I)	(J)	Mean Difference (I-J)	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
Group 1	Group 2	0.00667	0.996	-0.0712	0.0846
	Group 3	.13600*	0.001*, sig	0.0581	0.2139
	Group 4	.21600*	0.001*, sig	0.1381	0.2939
Group 2	Group 3	.12933*	0.001*, sig	0.0514	0.2072
	Group 4	.20933*	0.001*, sig	0.1314	0.2872
Group 3	Group 4	.08000*	0.042*, sig	0.0021	0.1579

Post hoc tukeys analysis, level of significance set at $p < 0.05$

4. Discussion

Salivary biomarkers have gained significant attention in recent years due to their potential role in non-invasive diagnostics for various oral diseases.[8] Among these, salivary albumin is of particular interest as it plays a role in maintaining oral homeostasis, inhibiting bacterial adhesion, and aiding in enamel remineralization.[9] Dental caries, a prevalent multifactorial disease, results from an imbalance between demineralization and remineralization processes. The assessment of salivary components, such as albumin, may provide insights into an individual's susceptibility to caries.[10,11] Understanding the correlation between salivary albumin and dental caries can help develop early detection tools and preventive strategies. This study builds on existing research by examining how salivary albumin levels vary across different DMFT categories and provides strong evidence of its inverse relationship with caries severity. The significant decline in albumin levels as DMFT scores increase underscores its potential as a non-invasive biomarker for caries risk assessment.

The findings of this study further establish a strong inverse relationship between salivary albumin levels and dental caries severity, as indicated by the significant ANOVA results and post-hoc analysis. The progressive decline in salivary albumin levels from Group 1 (0.34 ± 0.08 mg/mL) to Group 4 (0.12 ± 0.04 mg/mL) suggests that salivary albumin exerts a protective effect during the early and intermediate stages of the disease, potentially delaying progression until its depletion renders enamel more vulnerable. These results are consistent with findings of Khandelwal et al. (2019),[5] Hegde et al. (2014)[4] and Vaish et al. (2024)[7] who also reported significantly lower albumin levels in individuals with high DMFT scores. Greabu et al. (2012)[12] highlighted the antioxidant role of albumin in reducing bacterial-induced oxidative stress, which aligns with the results of our study indicating lower albumin concentrations in individuals with severe caries.[3] Our results further align with Martins et al.[6] and Alamoudi et al. (2022),[13] who emphasized the importance of salivary proteins in caries prevention, suggesting that role of albumin extends beyond antimicrobial properties to aiding enamel remineralization. A recent systematic review (2022)[14] also confirms the negative association between salivary albumin and caries, and

suggests that albumin's caries-limiting effect may be augmented by salivary mucins and lysozyme, supporting the concept of a protective proteomic network. Building upon our focus on albumin, a proteomic study by Khan et al. (2021)[15] identified significant differences in salivary protein expression and protease activity in caries patients, underlining the broader dysregulation of salivary proteome in disease states.

A deeper analysis of our post-hoc comparisons shows that while there was no significant difference between Group 1 and Group 2, there was a marked reduction in albumin levels from Group 2 to Group 3 ($p = 0.001$), reinforcing the idea that albumin depletion becomes clinically significant only once caries surpasses initial demineralization, reinforcing its potential role as a marker of disease severity rather than mere presence.

The dual role of albumin, however, remains a subject of debate. Research by Shore et al. (2000)[16] and Perez et al. (2020)[17] found albumin present in demineralized enamel, raising the possibility that while albumin serves a protective function, its presence in carious lesions may interfere with remineralisation, which could explain the progressive decline observed in our study. Mahmood et al. (2024) highlighted how salivary albumin levels are also indicative of systemic inflammatory conditions, suggesting that their decline in severe caries cases could be linked to broader inflammatory responses in the body.[18]

Taken together, these findings highlight both the diagnostic potential and mechanistic complexity of salivary albumin as a biomarker. Importantly, the present study contributes region-specific data from Haryana, addressing a notable gap in the literature where most studies have been confined to pediatric populations or geographically distinct cohorts.[1,2,19] By employing standardized saliva collection and DMFT scoring, our results strengthen the case for salivary albumin as a feasible marker of caries risk in adult populations.

Nevertheless, several limitations must be acknowledged. Being a cross-sectional study, causality between declining albumin levels and caries progression cannot be established. Variations in diet, oral hygiene habits, and systemic health conditions, factors known to influence salivary proteins[20] were not fully controlled, which may confound results. Additionally, while albumin appears promising, caries is multifactorial, and relying on a single biomarker may oversimplify its complex pathogenesis.

Given the significant differences observed in this study, future research should explore whether salivary albumin levels fluctuate in response to caries treatment and prevention efforts. Additionally, investigating interactions between albumin and other salivary proteins such as lactoferrin, cystatin, and mucins may provide a more comprehensive biomarker panel.[14] Our study adds to the growing body of evidence supporting the inverse relationship between salivary albumin and dental caries. The significant decline in albumin levels as DMFT scores increase underscores its potential as a non-invasive biomarker for caries risk assessment. Future research should aim to refine diagnostic thresholds and establish clinical applications for salivary albumin testing in preventive dentistry.

5. Conclusion

The findings of this study suggest that lower salivary albumin levels are associated with increased susceptibility to dental caries. More laboratory and clinical research is needed to pinpoint the precise mechanism of salivary albumin's ability to protect teeth from dental caries and to demonstrate its dependability as a useful indicator of caries risk.

6. Ethical Committee Approval

Ethical clearance was received from the institutional ethical committee for this in-vivo study.

7. Source of Funding

None.

8. Conflict of Interest

None.

9. Acknowledgement

None.

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