RESEARCH PAPER

Evaluation Of Salivary Albumin And Uric Acid As Biomarkers Of Healing After Scaling And Root Planing In Stage II–III, Grade B Periodontitis

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Abstract

Background: Periodontitis is a biofilm-initiated, host-mediated disease in which oxidative stress (os) amplifies tissue injury. Salivary antioxidants—particularly uric acid (ua) and albumin (alb)—offer a non-invasive window into redox status and therapeutic response.

Aim: The aim of this study is to evaluate the effect of scaling and root planing (srp) on salivary ua and alb in patients with Stage Ii–Iii, Grade B periodontitis.

Methods: A quasi-experimental, uncontrolled before-and-after study was conducted at the University Of Khartoum. Systematically healthy adults (≥18 years) with Stage Ii–Iii, Grade B periodontitis and ≥12 functional teeth were enrolled. Unstimulated saliva and full-mouth periodontal measurements were obtained at baseline and 4 weeks post-srp. Clinical indices included Plaque Index (Pi), Gingival Index (Gi), probing pocket depth (Ppd), And clinical attachment loss (Cal). Salivary ua (uricase–peroxidase) and alb (bromocresol green) were quantified spectrophotometrically. Paired t tests and Pearson correlations were applied (α=0.05). Intra-examiner reliability was strong (κ=0.8).

Results: Thirty-nine patients were analyzed (51.3% male; age 18–63 years). Srp produced significant improvements in Pi, Bop, And Cal (all p=0.001); Ppd change was not significant (p=0.381). Ua showed a non-significant increase (4.25±0.95 to 4.45±1.13 mg/dl; p=0.345). Alb increased significantly (0.15±0.13 to 0.22±0.17 g/dl; p=0.009). Alb improvement was evident across age strata and in males; females showed a similar but non-significant trend. No significant correlations were found between clinical indices and antioxidant levels at either time point.

Conclusions: Srp improves clinical periodontal status and enhances salivary albumin—supporting alb as a sensitive, non-invasive biomarker of short-term periodontal healing—while salivary uric acid appears less responsive over 4 weeks.

Clinical Significance: Incorporating salivary alb into follow-up may augment conventional clinical monitoring after nonsurgical periodontal therapy.

Keywords: Periodontitis, Scaling And Root Planing, Saliva, Albumin, Uric Acid, Oxidative Stress, Biomarkers, Staging And Grading (2017).

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Introduction

Periodontitis is a chronic, multifactorial inflammatory disease that progressively destroys the supporting structures of the teeth, ultimately leading to tooth loss if left untreated [1]. It arises from the persistent accumulation of subgingival microbial biofilms, but its clinical severity is largely determined by the host's inflammatory and immune response rather than by microbial virulence alone [2]. A growing body of evidence recognizes oxidative stress (OS) as a pivotal molecular mechanism underlying this dysregulated host–microbe interaction. Excessive generation of reactive oxygen species (ROS) by activated neutrophils and macrophages contributes to the degradation of extracellular matrix components, lipid peroxidation, and DNA oxidation, culminating in irreversible periodontal tissue destruction [3,4].

ROS such as superoxide anion ($O_2^{\bullet -}$), hydrogen peroxide (H_2O_2), and hydroxyl radicals (•OH) are physiologically generated as by-products of aerobic metabolism and play essential roles in cell signaling, microbial killing, and tissue repair [5]. However, when the balance between oxidant production and antioxidant defenses is disrupted, oxidative stress ensues. This redox imbalance drives a self-sustaining inflammatory cycle that perpetuates connective tissue damage and alveolar bone resorption [3,6]. The concept of oxidative stress in periodontitis is now considered part of a wider systemic phenomenon linking periodontal inflammation with extra-oral conditions including diabetes mellitus, cardiovascular disease, rheumatoid arthritis, and adverse pregnancy outcomes [4,7]. Indeed, elevated oxidative stress biomarkers have been observed both locally in the gingival crevicular fluid and systemically in the plasma of patients with periodontitis, supporting the view that periodontal inflammation contributes to a state of systemic oxidative burden [8,9].

The oral cavity, particularly saliva, provides a unique diagnostic window into this process. Saliva is a dynamic biological fluid containing numerous antioxidants derived from both local secretions and systemic circulation [10]. Among these, uric acid (UA) and albumin (ALB) are the principal non-enzymatic scavengers responsible for neutralizing free radicals and protecting oral tissues from oxidative damage [11,12]. UA, a terminal product of purine metabolism, accounts for more than 70 % of the total salivary antioxidant capacity, whereas albumin contributes through its redox-active thiol groups that quench reactive species and bind transition metals [13]. Alterations in salivary UA and ALB levels have therefore been proposed as reliable indicators of oxidative status in periodontal and systemic diseases. Because saliva collection is non-invasive and reproducible, it offers an appealing alternative to serum assays for monitoring disease progression and therapeutic response [14,15].

Scaling and root planing (SRP) remains the cornerstone of non-surgical periodontal therapy. Beyond mechanical removal of subgingival plaque and calculus, SRP reduces microbial load, attenuates inflammatory mediators, and promotes the restoration of tissue homeostasis [16]. Importantly, successful SRP is associated with a measurable decline in oxidative stress markers and a corresponding increase in antioxidant capacity [17]. These biochemical changes reflect not only local periodontal healing but also systemic benefits, since periodontal therapy has been shown to improve endothelial function and reduce systemic inflammatory burden. Consequently, assessing salivary antioxidant dynamics before and after SRP offers valuable insight into the biological efficacy of treatment and the potential of saliva as a surrogate indicator for periodontal recovery [18]. Therefore, the present study aimed to evaluate the effect of scaling and root planing on salivary uric acid and albumin levels in patients with periodontitis. By examining changes in these key antioxidants following non-surgical therapy, the study sought to elucidate whether periodontal treatment can restore redox equilibrium and thereby contribute to both oral and systemic health.

Materials and Methods

Study Design and Setting

This quasi-experimental, uncontrolled before-and-after study was conducted among patients attending the Department of Oral Rehabilitation, Faculty of Dentistry, University of Khartoum, Sudan. The study aimed to evaluate changes in salivary antioxidant levels following nonsurgical periodontal therapy.

Study Population

The study included systemically healthy adults diagnosed with periodontitis according to the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions, which replaced the 1999 system [19,20]. Patients were categorized as having Stage II or Stage III periodontitis with Grade B progression rate, determined based on clinical attachment loss (CAL), probing pocket depth (PPD), and radiographic bone loss pattern.

Eligibility Criteria

Inclusion criteria

- Adults aged ≥ 18 years with Stage II–III, Grade B periodontitis and ≥ 12 functional teeth (excluding third molars).
- Willingness to participate and provide written informed consent.

Exclusion criteria

- Systemic diseases known to influence periodontal status or salivary composition.
- Use of antibiotics or antioxidant/vitamin supplements during the previous 3 months.
- Periodontal therapy within the preceding 6 months.
- Smoking or tobacco use.
- Pregnancy, lactation, or hormonal-contraceptive use.

Sample Size Determination

Sample size was calculated for paired continuous variables with 95 % confidence (z_1–$\alpha/2 = 1.96$) and 80 % power (z_1–$\beta = 0.84$), assuming a mean difference of 44.47 and SD difference 68.7. The required sample was 39 patients, increased by 5 % to account for attrition, yielding a final sample of 41 participants.

Sampling Technique

A stratified systematic random sampling technique was adopted to ensure balanced representation and minimize selection bias. The total population consisted of patients attending the Department of Oral Rehabilitation, Faculty of Dentistry, University of Khartoum, during the study period. Eligible participants were first stratified according to gender (male and female strata) to account for potential sex-related variations in salivary biochemistry and periodontal disease presentation.

Within each stratum, patients meeting the inclusion criteria were systematically selected from the daily outpatient attendance registry. The sampling interval (k) was calculated by dividing the total number of eligible patients in each stratum by the number of required participants to be drawn from that stratum. The first participant in each stratum was chosen randomly using a simple random method (e.g., random number table), and every kth patient thereafter was included until the desired proportional sample size was achieved.

This proportional stratification maintained the natural distribution of gender in the clinic population, ensuring representativeness of both male and female patients in relation to their attendance frequency. Stratification by gender also permitted meaningful subgroup analyses to detect biochemical or clinical variations between sexes. The systematic component minimized examiner selection bias, while the stratified framework enhanced external validity by reflecting real-world clinic demographics.

The final sample therefore reflected a gender-balanced and attendance-proportional distribution of patients with Stage II–III, Grade B periodontitis who fulfilled all eligibility criteria. The sampling method ensured that the study cohort was representative of the clinical population routinely receiving nonsurgical periodontal therapy at the institution.

Examiner Calibration and Reliability

All examinations and measurements were performed by a single calibrated examiner. Intra-examiner reliability was assessed using the Kappa test, yielding a reliability coefficient of $\kappa = 0.8$, indicating strong agreement and ensuring measurement consistency.

Study Protocol

Participants attended two visits spaced four weeks apart:

Baseline visit:

- Unstimulated whole saliva was collected before periodontal measurements to prevent blood contamination.
- Full-mouth periodontal examination was performed, and results were recorded on standardized forms.
- Nonsurgical periodontal therapy (scaling and root planing, SRP) was completed after sampling.

Follow-up visit (four weeks post-SRP):

- Saliva collection was repeated using the same protocol.
- Clinical parameters were re-evaluated for comparison.

Saliva Collection and Storage

Unstimulated saliva was collected between 9:00 and 11:00 a.m. following the Navazesh (1993) protocol [21]. Participants abstained from food or beverages (except water) for one hour before collection. After rinsing with distilled water, each subject sat upright with the head slightly tilted forward, allowing saliva to drip passively into a sterile tube for five minutes. Samples were immediately placed on ice and stored at –80 °C until analysis.

Clinical Periodontal Assessment

Measurements were taken at six sites per tooth (mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual, disto-lingual) using a Michigan "O" probe with William's markings**.** Third molars were excluded. The following indices were recorded:

- Plaque Index (PI)
- Bleeding on Probing (BoP)
- Probing Pocket Depth (PPD)**:** distance from the gingival margin to pocket base
- Clinical Attachment Loss (CAL): distance from cementoenamel junction to pocket base.

Mean values were calculated per participant from all measured sites.

Periodontal Treatment

Full-mouth SRP was performed using both manual and ultrasonic instruments. Manual instrumentation utilized universal curettes and sickle scalers, while ultrasonic debridement employed a Woodpecker Ultrasonic Scaler (Model UDS-J, Guilin Woodpecker Medical Instrument Co., China)**.** Treatment was usually completed in two sessions (upper and lower arches). Post-therapy, patients received personalized oral-hygiene instruction. No antibiotics or antiseptic rinses were prescribed.

Biochemical Analyses

Salivary Uric Acid (UA)

UA levels were measured using the Uricase–Peroxidase enzymatic method (Biosystem™)**.** The resulting quinoneimine chromogen was read at 520 nm with a Visible Spectrophotometer (Model 722G)**.**

Salivary Albumin (ALB)

ALB was quantified via the Bromocresol Green (BCG) colorimetric assay (Biosystem™) at 630 nm using the same spectrophotometer.

All assays were performed in duplicate to ensure analytical precision.

Statistical Analysis

Data were analyzed with SPSS v22.0 (IBM Corp., Chicago, IL, USA)**.** Descriptive statistics (mean ± SD) summarized all variables. Differences before and after SRP were evaluated using paired-sample ***t*** tests, and Pearson's correlation assessed relationships between clinical and biochemical parameters. A $p \leq 0.05$ was considered statistically significant.

Ethical Considerations

The study protocol was approved by the Ethics Research Committee, Faculty of Medicine, University of Khartoum (Approval No.: FM/DO/EC/2019).

The purpose and procedures were explained to all participants, and written and verbal informed consent was obtained. Participants exhibiting periodontal disease received oral-hygiene instruction and appropriate nonsurgical treatment following ethical guidelines.

Statistical Analysis

SPSS v22 was used for data analysis. Paired-sample t-tests assessed pre- and post-treatment differences; Pearson correlation evaluated relationships between biochemical and clinical variables. Statistical significance was set at $p \leq 0.05$.

Results

A total of 39 patients with Stage II–III, Grade B periodontitis were enrolled in this quasi-experimental study. The sample comprised 20 males (51.3%) and 19 females (48.7%), aged between 18 and 63 years. Seventeen participants (43.6%) were below 40 years of age, while twenty-two (56.4%) were aged 40 years and above (Table 1).

Table 1. Frequency distribution of study participants by age

Age group (years)	Frequency (n)	Percentage (%)
< 40 years	17	43.6 %
≥ 40 years	22	56.4 %
Total	**39**	**100 %**

Changes in Clinical Periodontal Parameters

Table 2 summarizes the mean and standard deviation (mean ± SD) of clinical parameters before and after scaling and root planing (SRP). Significant improvements were observed in PI, BoP, and CAL after therapy ($p = 0.001$ for each). Mean PI decreased from 1.64 ± 0.25 at baseline to 1.42 ± 0.30 post-treatment, and

PoB reduced from 63.5 ± 12.4 to 38.6 ± 10.8. Similarly, CAL showed a significant reduction from 1.42 ± 1.22 to 1.11 ± 1.22. In contrast, changes in probing pocket depth (PPD) were not statistically significant (p = 0.381).

Table 2. Clinical periodontal parameters before and after scaling and root planing (SRP)

Parameter	Before SRP (Mean ± SD)	After SRP (Mean ± SD)	p value
Plaque Index (PI)	1.64 ± 0.25	1.42 ± 0.30	**0.001 ***
Bleeding on Probing (PoB)	63.5 ± 12.4	38.6 ± 10.8	**0.001 ***
Probing Pocket Depth (PPD mm)	0.52 ± 0.75	0.41 ± 0.89	0.381
Clinical Attachment Loss (CAL mm)	1.42 ± 1.22	1.11 ± 1.22	**0.001 ***

* Paired-samples *t* test; $p \leq 0.05$ considered significant.

Changes in Salivary Antioxidant Biomarkers

Mean salivary uric acid (UA) and albumin (ALB) concentrations before and after SRP are presented in Table 3.

UA levels increased slightly from 4.25 ± 0.95 mg/dL to 4.45 ± 1.13 mg/dL; however, this change was not statistically significant (p = 0.345).

Conversely, ALB levels demonstrated a significant increase from 0.15 ± 0.13 g/dL to 0.22 ± 0.17 g/dL (p = 0.009), indicating a notable improvement in antioxidant capacity following nonsurgical therapy.

Table 3. Salivary uric acid and albumin levels before and after SRP

Parameter	Before SRP (Mean ± SD)	After SRP (Mean ± SD)	p value
Uric acid (mg/dL)	4.25 ± 0.95	4.45 ± 1.13	0.345
Albumin (g/dL)	0.15 ± 0.13	0.22 ± 0.17	0.009 *

* Paired-samples *t* test; $p \leq 0.05$ considered significant.

Gender-Based Differences

Table 4 illustrates the gender-wise comparison of antioxidant levels. Among male patients, UA increased from 4.3 ± 1.0 mg/dL to 4.8 ± 1.1 mg/dL (p = 0.084, not significant), whereas ALB rose significantly from 0.10 ± 0.10 g/dL to 0.20 ± 0.20 g/dL (p = 0.043).

In contrast, female participants exhibited no significant changes in either biomarker. UA decreased slightly from 4.2 ± 1.0 mg/dL to 4.1 ± 1.1 mg/dL (p = 0.770), and ALB showed a marginal, non-significant increase from 0.20 ± 0.20 g/dL to 0.20 ± 0.20 g/dL (p = 0.082).

Table 4. Comparison of salivary uric acid and albumin levels by gender

Parameter	Gender	n	Before SRP (Mean ± SD)	After SRP (Mean ± SD)	p value
Uric acid (mg/dL)	Male	20	4.3 ± 1.0	4.8 ± 1.1	0.084
	Female	19	4.2 ± 1.0	4.1 ± 1.1	0.770
Albumin (g/dL)	Male	20	0.10 ± 0.10	0.20 ± 0.20	**0.043 ***
	Female	19	0.20 ± 0.20	0.20 ± 0.20	0.082

* Paired-samples *t* test; $p \leq 0.05$ considered significant.

Age-Based Differences

Age-stratified analysis (Table 5) showed that UA changes were not statistically significant in either age group. Among patients younger than 40 years, UA increased from 4.3 ± 1.1 mg/dL to 4.6 ± 1.1 mg/dL (p = 0.236). For those aged 40 years and above, UA rose minimally from 4.2 ± 0.8 mg/dL to 4.3 ± 1.1 mg/dL (p = 0.762).

However, ALB levels significantly improved in both groups: in participants < 40 years, from 0.20 ± 0.10 g/dL to 0.20 ± 0.10 g/dL (p = 0.029), and in those ≥ 40 years, from 0.10 ± 0.20 g/dL to 0.20 ± 0.20 g/dL (p = 0.047).

Table 5. Comparison of salivary uric acid and albumin levels by age group

Parameter	Age group (years)	n	Before SRP (Mean ± SD)	After SRP (Mean ± SD)	p value
Uric acid (mg/dL)	< 40	17	4.3 ± 1.1	4.6 ± 1.1	0.236

	≥ 40	22	4.2 ± 0.8	4.3 ± 1.1	0.762
Albumin (g/dL)	< 40	17	0.20 ± 0.10	0.20 ± 0.10	**0.029 ***
	≥ 40	22	0.10 ± 0.20	0.20 ± 0.20	**0.047 ***

* Paired-samples *t* test; $p \leq 0.05$ considered significant.

Correlations between Clinical and Biochemical Parameters

Pearson's correlation analysis (Tables 6 and 7) revealed no statistically significant associations between salivary UA or ALB and any of the clinical periodontal parameters (PI, BoP, PPD, or CAL) either before or after SRP.

Table 6. Pearson correlation coefficients (r) and p-values between clinical periodontal parameters and salivary antioxidants before scaling and root planing (SRP)

Clinical Parameter	Uric Acid (r)	p-value	Albumin (r)	p-value
PI	–0.004	0.981	0.139	0.399
BoP	–0.028	0.867	–0.015	0.930
PPD	–0.050	0.763	0.231	0.157
CAL	0.121	0.465	–0.002	0.991

All p > 0.05; no statistically significant correlations were observed between clinical parameters and salivary antioxidants before SRP.

Table 7. Pearson correlation coefficients (r) and corresponding p-values between clinical periodontal parameters and salivary antioxidants after scaling and root planing (SRP)

Clinical parameter	Uric Acid (r)	p-value	Albumin (r)	p-value
PI	0.04	0.812	0.02	0.899
BoP	–0.02	0.909	–0.14	0.413
PPD	–0.08	0.630	0.05	0.759
CAL	0.13	0.438	–0.08	0.626

All p > 0.05; no statistically significant correlations were observed.

Discussion

The present study investigated the clinical and biochemical effects of nonsurgical periodontal therapy on salivary antioxidants—uric acid and albumin—among patients diagnosed with Stage II–III, Grade B periodontitis according to the 2017 World Workshop classification [19,20].

Clinical Improvements after SRP

The marked reduction in plaque and gingival indices after SRP confirms the fundamental role of mechanical debridement in disrupting bacterial biofilms and reducing the inflammatory burden [22]. Similar findings have been consistently reported across multiple studies. For instance, Pihlstrom et al. and Cobb et al. demonstrated significant improvement in gingival inflammation and attachment levels following mechanical therapy, highlighting its biological efficacy in modulating host inflammatory responses [23,24]. The non-significant change in probing pocket depth observed in the current cohort may be attributed to the relatively shallow baseline pockets characteristic of Stage II–III periodontitis [20], where the clinical effect of SRP is expressed more through resolution of inflammation and gain of attachment rather than substantial pocket reduction. Studies by Werner and colleagues have emphasized that pocket depth reduction is proportional to initial probing depth and tissue inflammatory status, supporting this interpretation [25].

Changes in Salivary Antioxidant Profile

A principal finding of this study was the significant post-therapeutic increase in salivary albumin. Albumin, a multifunctional protein possessing redox-active thiol groups, acts as a first-line scavenger against reactive oxygen species (ROS) and a stabilizer of oxidative equilibrium in both plasma and saliva [26]. Its elevation following SRP likely reflects the resolution of local inflammatory exudation and restoration of salivary gland function. Several previous investigations corroborate this observation [12,27,28]. Sayar et al. and Novakovic et al. reported significant increases in salivary albumin and total antioxidant capacity after nonsurgical periodontal therapy, attributing these changes to reduced epithelial permeability and enhanced antioxidant replenishment once inflammatory challenge subsides [27,28]. Therefore, the consistent trend across literature supports albumin as a sensitive biomarker reflecting therapeutic resolution in periodontal disease [29, 30].

In contrast, the modest, statistically insignificant rise in salivary uric acid observed in this study aligns with earlier reports that identified uric acid as a relatively stable systemic antioxidant with limited short-term responsiveness to local periodontal therapy [31]. Uric acid constitutes nearly 70–80% of total salivary

antioxidant activity, but its levels are heavily influenced by systemic metabolism, dietary intake, and renal clearance rather than solely local inflammation [32,33]. Previous studY by Zhao et al. found no significant post-treatment variation in uric acid levels, supporting the current findings [34]. However, some authors, including Novakovic and Lopes, have demonstrated significant increases in uric acid following SRP or antioxidant supplementation, implying that metabolic or nutritional modulation may enhance this response over longer follow-up periods [35,36]. Therefore, the four-week interval used in this study may not have been sufficient to capture delayed metabolic adjustments in uric acid turnover.

Gender-Based Differences

The gender-specific analysis revealed that male participants exhibited a significant increase in salivary albumin after therapy, whereas the change among females was not significant. This difference may reflect gender-related variations in oxidative metabolism and salivary protein expression. Testosterone has been reported to influence antioxidant enzyme activity, while estrogen exhibits complex effects on inflammatory modulation and salivary secretion [37,38]. Studies by Chung et al. has similarly noted higher salivary antioxidant responsiveness among males following periodontal therapy [39]. In contrast, research by Shirzaiy et al. and Prodan found comparable antioxidant shifts between genders, indicating that hormonal influences may be subtle and context-dependent [40,41]. The lack of a significant change among females in the present study may reflect physiological variability in salivary protein dynamics or the reduced subgroup sample size, which could have attenuated statistical sensitivity to detect subtle biochemical differences [42].

Age-Related Variations

The significant improvement in albumin levels across both younger and older patients emphasizes that the redox restorative effect of SRP is consistent regardless of age [43]. However, the lack of significant uric acid change among older patients may reflect age-related oxidative stress accumulation and reduced metabolic clearance, which collectively blunt biochemical recovery [44]. Previous research demonstrated attenuated antioxidant responses in older adults with periodontitis, attributing this to diminished salivary gland reserve and persistent low-grade systemic inflammation [45,46]. Nonetheless, the similar direction of change in both age groups observed in the current study supports the potential benefit of SRP across the lifespan in mitigating local oxidative burden.

Correlations between Clinical and Biochemical Parameters

Before periodontal therapy, no statistically significant correlations were detected between the recorded clinical parameters (PI, BoP, PPD and CAL) and salivary antioxidant markers (UA and ALB). This lack of association likely reflects the distinct biological domains captured by clinical and biochemical measurements. Clinical indices represent site-specific inflammatory and structural changes, whereas salivary antioxidants reflect a composite redox balance derived from both systemic and glandular sources [47]. Oxidative stress in periodontitis is a dynamic, multifactorial process influenced not only by local inflammation but also by systemic metabolic regulation, diet, and salivary secretion rate. Consequently, direct linear relationships may not emerge when these markers are evaluated cross-sectionally [47].

Moreover, oxidative stress biomarkers often exhibit threshold or nonlinear behavior, where biochemical perturbations precede overt clinical manifestations. In untreated periodontitis, the antioxidant system may already be compensating for chronic oxidative load, producing heterogeneous biochemical profiles that do not parallel clinical severity. These observations are consistent with previous findings by Zhang et al. who similarly reported weak or absent baseline correlations and emphasized that salivary biomarkers act as early indicators of host oxidative response rather than direct surrogates of clinical destruction [48].

After scaling and root planing, the correlations between periodontal indices and salivary antioxidant levels remained statistically insignificant, despite the clear clinical improvement and significant rise in albumin concentration. This apparent dissociation underscores that biochemical recovery does not necessarily occur in direct proportion to clinical healing within the short-term post-therapy window. The resolution of inflammation and restoration of epithelial integrity following SRP can normalize salivary composition at variable rates among individuals, depending on their metabolic adaptation, glandular function, and redox reserve capacity. Hence, while clinical indices rapidly improve through mechanical plaque removal, antioxidant markers may

continue to fluctuate as part of a delayed homeostatic adjustment phase [47].

The consistent absence of strong correlations in both phases therefore highlights the complementary rather than interchangeable nature of clinical and biochemical assessments. Clinical indices provide macroscopic evidence of inflammation resolution, whereas salivary antioxidants reveal the microscopic biochemical trajectory toward redox balance. Together, these domains form a more comprehensive picture of periodontal healing. Longitudinal monitoring with extended follow-up and inclusion of broader oxidative stress panels—such as total antioxidant capacity and lipid peroxidation markers—could further elucidate the temporal coupling between clinical recovery and antioxidant normalization.

Biological Interpretation and Clinical Implications

Taken together, these findings underscore the dual therapeutic impact of SRP—mechanical removal of bacterial biofilm and indirect modulation of oxidative stress through reduced inflammatory activity. The significant rise in salivary albumin supports its utility as a noninvasive biomarker for assessing periodontal healing. Given its responsiveness to therapy, cost-effective assay methods, and reproducibility, albumin could be integrated into chairside diagnostic panels for monitoring patient response in routine periodontal practice. Conversely, uric acid, though abundant, may serve better as a background indicator of systemic oxidative capacity rather than a dynamic local marker. The results affirm the emerging view that salivary antioxidants offer a biochemical window into the inflammatory resolution phase of periodontitis treatment.

Limitations and Future Directions

While the study design and biochemical rigor provide reliable evidence, the relatively short follow-up period may have limited the observation of long-term antioxidant recovery. Expanding the time frame and incorporating additional oxidative stress markers—such as total antioxidant capacity, glutathione peroxidase, and malondialdehyde—would yield a more comprehensive picture of redox dynamics. Furthermore, correlating salivary findings with serum or gingival crevicular fluid biomarkers could clarify the extent to which local improvements reflect systemic antioxidant modulation.

Conclusion

Within the limitations of this study, nonsurgical periodontal therapy effectively improved both clinical periodontal parameters and salivary antioxidant status among patients with Stage II–III, Grade B periodontitis. Scaling and root planing led to significant reductions in plaque accumulation, gingival inflammation, and clinical attachment loss, confirming its therapeutic efficacy. The marked increase in salivary albumin after treatment reflects a restoration of local redox balance and highlights its potential as a sensitive, non-invasive biomarker for monitoring periodontal healing.

Although salivary uric acid showed a mild upward trend without statistical significance, this stability likely reflects its systemic regulation and slower responsiveness to local therapy. The absence of direct correlations between biochemical and clinical parameters suggests that oxidative markers complement, rather than replace, conventional clinical assessment.

Overall, these findings reinforce the biological role of mechanical periodontal therapy in re-establishing host antioxidant defense and provide additional support for incorporating salivary biomarkers—particularly albumin—into future diagnostic and follow-up strategies. Long-term, controlled studies with larger cohorts and broader oxidative stress panels are warranted to confirm these observations and clarify the mechanistic pathways linking periodontal inflammation and antioxidant modulation.

References

1. Könönen E, Gursoy M, Gursoy UK. Periodontitis: A multifaceted disease of tooth-supporting tissues. J Clin Med. 2019;8(8):1135. https://doi.org/10.3390/jcm8081135
2. Abdulkareem AA, Al-Taweel FB, Al-Sharqi AJ, Gul SS, Sha A, Chapple IL. Current concepts in the pathogenesis of periodontitis: From symbiosis to dysbiosis. J Oral Microbiol. 2023;15(1):2197779. https://doi.org/10.1080/20002297.2023.2197779
3. Liu S, Liu J, Wang Y, Deng F, Deng Z. Oxidative stress: Signaling pathways, biological functions, and disease. MedComm. 2025;6(7):e70268. https://doi.org/10.1002/mco2.70268
4. Shang J, Liu H, Zheng Y, Zhang Z. Role of oxidative stress in the relationship between periodontitis and systemic diseases. Front Physiol. 2023;14:1210449. https://doi.org/10.3389/fphys.2023.1210449

5. Juan CA, Plou FJ, Pérez-Lebeña E. The chemistry of reactive oxygen species (ROS) revisited: Outlining their role in biological macromolecules and induced pathologies. Int J Mol Sci. 2021;22(9):4642. https://doi.org/10.3390/ijms22094642
6. Bellanti F, Daniela Coda AR, Trecca MI, Buglio AL, Serviddio G, Vendemiale G. Redox imbalance in inflammation: The interplay of oxidative and reductive stress. Antioxidants. 2025;14(6):656. https://doi.org/10.3390/antiox14060656
7. Isola G, Polizzi A, Serra S, Boato M, Sculean A. Relationship between periodontitis and systemic diseases: A bibliometric and visual study. Periodontol 2000. 2025;98(1):228–240. https://doi.org/10.1111/prd.12621
8. Becerik S, Öztürk VÖ, Celec P, Kamodyova N, Atilla G, Emingil G. Gingival crevicular fluid and plasma oxidative stress markers and TGM-2 levels in chronic periodontitis. Arch Oral Biol. 2017;83:47–54. https://doi.org/10.1016/j.archoralbio.2017.06.032
9. Mohideen K, Chandrasekaran K, Veeraraghavan H, Faizee SH, Dhungel S, Ghosh S. Meta-analysis of assessment of total oxidative stress and total antioxidant capacity in patients with periodontitis. Dis Markers. 2023;2023:9949047. https://doi.org/10.1155/2023/9949047
10. Javaid MA, Ahmed AS, Durand R, Tran SD. Saliva as a diagnostic tool for oral and systemic diseases. J Oral Biol Craniofac Res. 2016;6(1):66–75. https://doi.org/10.1016/j.jobcr.2015.08.006
11. Jaiswal A, Madaan S, Acharya N, Kumar S, Talwar D, Dewani D. Salivary uric acid: A noninvasive wonder for clinicians? Cureus. 2021;13(11):e19649. https://doi.org/10.7759/cureus.19649
12. Surdu A, Foia LG, Luchian I, Trifan D, Tatarciuc MS, Scutariu MM, Ciupilan C, Budala DG. Saliva as a diagnostic tool for systemic diseases—A narrative review. Medicina. 2025;61(2):243. https://doi.org/10.3390/medicina61020243
13. Bakhtiari S, Toosi P, Samadi S, Bakhshi M. Assessment of uric acid level in the saliva of patients with oral lichen planus. Med Princ Pract. 2016;26(1):57–60. https://doi.org/10.1159/000452133
14. Li Y, Ou Y, Fan K, Liu G. Salivary diagnostics: Opportunities and challenges. Theranostics. 2024;14(18):6969–6987. https://doi.org/10.7150/thno.100600
15. Sánchez-Villamil JP, Pino-Vélez C, Trejos-Suárez J, Cardona N, España AL, Alfonso PA. Salivary markers of oxidative stress and periodontal pathogens in patients with periodontitis from Santander, Colombia. Biomédica. 2020;40(Suppl 1):113–124. https://doi.org/10.7705/biomedica.5149
16. Cobb CM, Sottosanti JS. A re-evaluation of scaling and root planing. J Periodontol. 2021;92(10):1370–1378. https://doi.org/10.1002/JPER.20-0839
17. Papadakis KA, Doufexi E, Kalamaki MS, Bourazanas E, Lymperaki E. The role of oxidative stress in the relationship between periodontitis and Alzheimer's disease. J Pers Med. 2025;15(8):384. https://doi.org/10.3390/jpm15080384
18. Ferrara E, Bassignani J, Di Tanna I, Murmura G, Balice G. The periodontal–cardiovascular disease association: Molecular mechanisms and clinical implications. Int J Mol Sci. 2024;26(16):7710. https://doi.org/10.3390/ijms26167710
19. Caton JG, Armitage G, Berglundh T, Chapple LC, Jepsen S, Kornman KS, Mealey BL, Papapanou PN, Sanz M, Tonetti MS. A new classification scheme for periodontal and peri-implant diseases and conditions. J Periodontol. 2018;89(Suppl 1):S1–S8. https://doi.org/10.1002/JPER.18-0157
20. Papapanou PN, Sanz M, Buduneli N, Dietrich T, Feres M, Fine DH, Flemmig TF, Garcia R, Giannobile WV, Graziani F, et al. Periodontitis: Consensus report of workgroup 2 of the 2017 World Workshop. J Periodontol. 2018;89(Suppl 1):S173–S182. https://doi.org/10.1002/JPER.17-0721
21. Navazesh M. Methods for collecting saliva. Ann N Y Acad Sci. 1993;694:72–77.

https://doi.org/10.1111/j.1749-6632.1993.tb18343.x

22. Tomasi C, Abrahamsson KH, Apatzidou D. Subgingival instrumentation. Periodontol 2000. 2023;93:1–13. https://doi.org/10.1111/prd.12485
23. Pihlstrom BL, McHugh RB, Oliphant TH, Ortiz-Campos C. Comparison of surgical and nonsurgical treatment of periodontal disease. J Clin Periodontol. 1983;10(5):524–541. https://doi.org/10.1111/j.1600-051x.1983.tb02182.x
24. Cobb CM. Clinical significance of non-surgical periodontal therapy. J Clin Periodontol. 2002;29(Suppl 2):22–32. https://doi.org/10.1034/j.1600-051X.29.s2.4.x
25. Werner N, Heck K, Walter E, Ern C, Bumm CV, Folwaczny M. Probing pocket depth reduction after non-surgical periodontal therapy. J Periodontol. 2024;95(1):29–39. https://doi.org/10.1002/JPER.23-0285
26. Seidkhani-Nahal A, Allameh A, Soleimani M. Antioxidant and reactive oxygen species scavenging properties of cellular albumin. Biotechnol Appl Biochem. 2019;66(2):163–171. https://doi.org/10.1002/bab.1708
27. Sayar F, Ahmadi RS, Montazeri M. Effect of nonsurgical periodontal therapy on salivary antioxidants. J Adv Periodontol Implant Dent. 2019;11(1):21–26. https://doi.org/10.15171/japid.2019.004
28. Novaković N, Cakić S, Todorović T, Raicević BA, Dozić I, Petrović V, Perunović N, Gostović SS, Sretenović JK, Colak E. Antioxidative status of saliva before and after periodontal treatment. Srp Arh Celok Lek. 2013;141(3–4):163–168. https://doi.org/10.2298/sarh1304163n
29. Xiang J, Cai Y, Yu Q, Zhu Z, Wang Y, Chen R. Association between serum albumin and periodontitis across disease subgroups. Int Dent J. 2025;75(4):100808. https://doi.org/10.1016/j.identj.2025.03.017
30. Kaur N, Kaur N, Sarangal V. A study to evaluate the correlation of serum albumin levels with chronic periodontitis. Indian J Dent Res. 2015;26(1):11–14. https://doi.org/10.4103/0970-9290.156788
31. Lorente L, Marrero EH, Abreu-Gonzalez P, Lorente Martín AD, González-Rivero AF, Marrero González MJ, Marrero CH, Marrero OH, Jiménez A, Hernández Padilla CM. Low salivary uric acid levels and periodontitis. World J Clin Cases. 2025;13(21):105911. https://doi.org/10.12998/wjcc.v13.i21.105911
32. Shi D, Ding J, Tian J. Salivary uric acid in periodontitis: Mechanistic insights and future trajectories. World J Clin Cases. 2025;13(27):108117. https://doi.org/10.12998/wjcc.v13.i27.108117
33. Du L, Zong Y, Li H, Wang Q, Xie L, Yang B, Pang Y, Zhang C, Zhong Z, Gao J. Hyperuricemia and related diseases: Mechanisms and advances in therapy. Signal Transduct Target Ther. 2024;9:212. https://doi.org/10.1038/s41392-024-01916-y
34. Zhao L, Yu T. Association between periodontitis and uric acid levels in blood and oral fluids: A systematic review and meta-analysis. BMC Oral Health. 2023;23:178. https://doi.org/10.1186/s12903-023-02900-8
35. Novakovic N, Todorovic T, Rakic M, Milinkovic I, Dozic I, Jankovic S, Aleksic Z, Cakic S. Salivary antioxidants as periodontal biomarkers in evaluation of tissue status and treatment outcome. J Periodontal Res. 2014;49(1):129–136. https://doi.org/10.1111/jre.12088
36. Lopes Castro MM, Duarte NN, Nascimento PC, Magno MB, Fernandes Fagundes NC, Flores-Mir C, Monteiro MC, Rösing CK, Maia LC, Lima RR. Antioxidants as adjuvants in periodontitis treatment: A systematic review and meta-analysis. Oxid Med Cell Longev. 2019;2019:9187978. https://doi.org/10.1155/2019/9187978
37. Tóthová L, Ostatníková D, Šebeková K, Celec P, Hodosy J. Sex differences of oxidative stress markers in young healthy subjects. Ann Hum Biol. 2013;40(2):175–180. https://doi.org/10.3109/03014460.2012.754495
38. Kander MC, Cui Y, Liu Z. Gender difference in oxidative stress and cardiovascular diseases. J Cell Mol Med. 2017;21(5):1024–1033. https://doi.org/10.1111/jcmm.13038
39. Chung C, Chan C. Use of serum albumin levels and salivary biomarkers in assessing

periodontal disease. BMC Oral Health. 2025;25:679. https://doi.org/10.1186/s12903-025-06042-x

40. Shirzaiy M, Ansari SM, Dehghan JH, Ghaeni SH. Total antioxidant capacity of saliva in chronic periodontitis before and after treatment. J Nepal Health Res Counc. 2014;12(28):172–176. PMID: 26032054
41. Prodan A, Brand HS, Ligtenberg AJ, Imangaliyev S, Tsivtsivadze E, van der Weijden F, Crielaard W, Keijser BJ, Veerman EC. Interindividual variation and sex-related differences in salivary biochemistry. Eur J Oral Sci. 2015;123(3):149–157. https://doi.org/10.1111/eos.12182
42. Castro MML, Ferreira MKM, Prazeres IEE, et al. Is the use of contraceptives associated with periodontal diseases? BMC Womens Health. 2021;21:48. https://doi.org/10.1186/s12905-021-01180-0
43. Riviati N, Indrajaya T, Saleh I, Ali Z, Indra B. Serum albumin as prognostic marker for older adults. Gerontol Geriatr Med. 2024;10:23337214241249914. https://doi.org/10.1177/23337214241249914
44. Guo M, Liu T, He R, Wu S, Tseng T, Wu C, Wu C. Differential relationship of uric acid to mortality and biomarkers of aging. Aging (Albany NY). 2021;13(7):10555–10570. https://doi.org/10.18632/aging.202820
45. Ungureanu LB, Grădinaru I, Ghiciuc CM, Amălinei C, Geleţu GL, Petrovici CG, Stănescu RS. Atrophy and inflammatory changes in salivary glands induced by oxidative stress. Medicina. 2023;59(9):1692. https://doi.org/10.3390/medicina59091692
46. Celec P. Oxidative stress and antioxidants in the diagnosis and therapy of periodontitis. Front Physiol. 2017;8:1055. https://doi.org/10.3389/fphys.2017.01055
47. Punj A, Shenoy S, Kumari NS, Pampani P. Estimation of antioxidant levels in saliva and serum of chronic periodontitis patients. Int J Dent. 2017;2017:1965697. https://doi.org/10.1155/2017/1965697
48. Zhang T, Andrukhov O, Haririan H, Müller-Kern M, Liu S, Liu Z, Rausch-Fan X. Total antioxidant capacity and total oxidant status in saliva of periodontitis patients. Front Cell Infect Microbiol. 2016;5:97. https://doi.org/10.3389/fcimb.2015.00097

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