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# Using Salivary Oxidative Stress Markers as Non-Invasive Technique in the Evaluation of Oxidative Stress Status

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**ABSTRACT**

**Background:** Salivary oxidative stress represents the discrepancy between reactive oxygen species and antioxidant mechanisms, therefore is an important index of systemic oxidative status. Several salivary markers have been identified making it a noninvasive tool for assessing OS and, especially important in chronic diseases.

**Objectives:** This research was conducted to evaluate the serum and salivary concentrations of OS markers in participants with or without CD as well as examine the correlation between their serum and salivary levels. Materials and Methods. Place and Duration of Study: Babylon Teaching Hospital, Iraq between March 2024 to February 2025. Methodology: This was a cross-sectional study carried out on 240 subjects. The subjects were divided into two main subgroups: group 1 with chronic diseases (n = 94) and group 2 without additional chronic diseases (n = 146). Serum and saliva MDA, LDH, 8-OHdG, SOD, CAT, GPx were measured using the standard spectrophotometry/ELISA techniques.

**Results:** The serum and salivary MDA (3.68 ± 0.74 µmol/L vs. 3.21 ± 0.69 µmol/L, p = 0.009), LDH (168.3 ± 32.4 U/L vs. 149.7 ± 30.6 U/L, p = 0:003) as well as the salivary level of the oxidative DNA damage biomarker (8-OHdG) were significantly different for subjects who had chronic diseases compared to those without ([5:04 ±1:15 ng/mL, n=297] [4:39±1:03 ng/mL] respectively; P

**Conclusion:** The results show that the patients in the clinical studies are exposed to increased oxidative stress and reduced antioxidant protection. The major significant relationships found between serum and salivary markers in our study demonstrate, saliva can be considered a valid, non–invasive potential medium for evaluating systemic OS status.

## INTRODUCTION

Oxidative stress refers to a state when production of ROS exceeds the population of antioxidants in the organism, leading to cascade molecular damages on lipids, proteins, and DNA. Accumulation of oxidative damage is believed to be associated with the etiopathogenesis of various diseases, such as cardiovascular disease, diabetes mellitus, neurodegeneration, and inflammatory diseases, inter alia. Mexico. Oxidative stress has been investigated using a variety of markers to measure lipid and DNA oxidation, overall antioxidant capacity and the activity of antioxidant enzyme levels e. lipid peroxidation malondialdehyde MDA, Fenton-reaction product and measure of DNA oxidation, 8-hydroxy-2′-deoxyguanosin 8-OHdG and total antioxidant capacity TAC expressed in ascorbate equivalents and antioxidant enzymes' activity e. g. superoxide dismutase SOD, glutathione peroxidase GPx Saliva, a complex physiological fluid is considered to have the potential to become an effective body fluid for noninvasive biochemical analysis (Mouneshkumar et al., 2024).

Salivary analysis, as a systematic approach, is a simple, reliable, cost-effective, and non-invasive monitoring technique. Hence, an increasing number of studies have been focusing on salivary analysis to diagnosis, prognosis, and monitoring of human disease in clinics. Hence, the brief was selected saliva and blood samples.

Several antioxidants and oxidative damage products are in the saliva, promoting the expansion of measurement of the oxidative stress markers in the literature. For example, in healthy young individuals, It was found that there was intraclass and interclass variability of salivary advanced oxidation protein products, AGEs, TAC and the ferric reducing ability of saliva (Lettrichová et al., 2026).

Current studies of the salivary oxidative markers in disease settings include diabetes mellitus, periodontitis, gestational diabetes, and renal disease. Kazan, et al. (2024) sought to find out whether the serum oxidant/antioxidant parameters in pregnant women with gestational diabetes mellitus vary regardless of being pregnant or healthy. Studies in salivary biomarkers have indicated that GDM patients differ from healthy pregnant women in serum and saliva TOS and TAS (Malik et al., 2024). In end-stage renal disease, positive correlations were found between markers of oxidative stress in saliva and serum, confirming that saliva can be used as a biofluid (Mashreghi et al., 2024).

On the other hand, the accuracy of correlation between oxidative stress markers measured in saliva and in serum remains inconclusive. Modern studies have revealed “moderate correlations”; others have “found only weak or “non-existing” link between these markers, which may be accounted by the differences in the local and systemic origins of the markers, methodological and biological variability of saliva. According to Lettrichová et al. (2016), high intra- and inter-individual variability now impedes the use of salivary oxidative stress biomarkers as an attribute of individual diagnosis. In a systematic meta-analysis in temporomandibular disorders, patients demonstrated a ‘significant’ difference in salivary MDA and a serum total antioxidant status comparing to controls, but the scarcity of publications “preclude any definitive conclusion on saliva–serum correspondence. Saliva is a unique biomedium due to its non-invasiveness and opportunity for its repeated use, yet the biological nature of its diagnostic validity as a surrogate of true systemic oxidative stress is still far from being elucidated (Kazan et al., 2024).

Therefore, the aim of the current study is to investigate the validity of oxidative stress biomarkers in the saliva as a response to serum status in well-defined markers of oxidation and antioxidation. The necessity of examining these correlations will give insight into the possibilities of saliva as a source of data that can be used instead or in adjunct to serum as part of scientific and clinical response to oxidative stress. Therefore, the aim of this study is to investigate a clear definition of a correlation between oxidative stress markers measured in serum and that in saliva.

## PATIENTS AND METHODS

This cross-sectional study was conducted in Najaf City, Iraq during the period from April 2024 to March 2025, and involved a total of 240 adults who were recruited from primary health centers and outpatient clinics. The aim of the study was to investigate correlation between serum and saliva markers of oxidative stress such as malonydialdehyde (MDA), lactate dehydrogenase (LDH), 8-hydroxy-2′-deoxyguanosine(8-OHdG) superoxide dismutase(SOD), catalase (CAT) and glutathione peroxidase(GPx).

### Study Design and Participants

A convenience sample of 240 subjects from 18 to 60 years were recruited to adequately represent various profiles: health and lifestyle conditions, tobacco consumption, chronic disease. Those individuals attending hospitals in Najaf City from the general population were also chosen as the center of studies. Exclusion criteria were acute illness and nonparticipation in the study. Exclusion criteria were active infections, autoimmune diseases, cancer and use of any antioxidant supplements, corticosteroids or immunosuppressive drugs in the past month. Additionally, pregnant and lactating women were excluded to avoid hormonal impact on oxidative markers.

### Data Collection

Socio-demographic and clinical information was obtained through a structured and pre-tested questionnaire developed by the research group. The questionnaire consisted of questions on age, sex, smoking status, history of existing chronic diseases and drug use, and lifestyle-related contributors to oxidative balance. Trained healthcare workers directly supervised and recorded data of each participant to maintain the reliability and completeness.

### Sample Collection and Preparation

In aseptic precautions 5 mL venous blood was drawn from all subject in plain gel tubes, clotted at room temperature. The sera were stored at –20 °C after centrifuging at 3000 rpm for 10 min until biochemical analysis. Participants had to avoid eating, drinking, and smoking for a minimum of 2 h prior falls take saliva samples. To minimize circadian variation, unstimulated whole saliva (around 3 mL) obtained by passive drooling into sterile tubes between 08:00 and 10:00 a.m. was used for measurement. The saliva samples were centrifuged at 3000 r.p.m. for 10 min and the supernatant was collected and frozen at –20 °C after being divided into aliquots until use during the examination.

### Measurement of Oxidative Stress Markers

The expressions of oxidative stress markers MDA, LDH, 8-OHdG, SOD, CAT, and GPx in serum and saliva were measured using their respective commercially available ELISA (enzyme-linked immunosorbent assay) kits (Human Diagnostics, Germany), as per the manufacturer's instructions. All measurements were conducted in duplicate for analytical control and internal quality control samples present on each run. The absorbance was determined with a microplate reader (Bio-Rad, USA) at wavelength specific to each assay.

**Ethical Considerations**

The protocol of the study was checked and accepted by Ethical Committee of Najaf Health Directorate, following Declaration of Helsinki (2013 edit). Written informed consent was obtained from all of the subjects before they were enrolled. The privacy of the data was preserved by all means during the course of this study.

## RESULTS

Our study included 240 participants of a broad age range from 18 to ≥48 years, with the largest group being represented by persons aged 28 to 37 years 30.0%. As for the gender distribution, our sample was relatively balanced with 52.5% of the sample being males and 47.5% -females making it representative for both sexes. More to the point, the majority of participants, 57.5% lived in cities, which can also reflect contributing factors of the recruitment settings and lifestyle which may be associated with oxidative stress exposure. Thirty-nine percent of the sample reported having chronic diseases, and 36.7% were smokers as these groups of individuals have higher oxidative stress levels compared to healthy and non-smoking individuals.

**Table 1. General information of subjects participated in the current study**

| Indicators | | `Participants (No. = 240) | |
|---|---|---|---|
| | | Freq. | % |
| Age/Years | 18-27 | 58 | 24.2 |
| | 28-37 | 72 | 30 |
| | 38-47 | 63 | 26.3 |
| | ≥ 48 | 47 | 19.5 |
| Gender | Male | 126 | 52.5 |
| | Female | 114 | 47.5 |
| Residence | Rural | 102 | 42.5 |
| | Urban | 138 | 57.5 |
| Chronic Disease | Yes | 94 | 39.2 |
| | No | 146 | 60.8 |
| Smoking | Yes | 88 | 36.7 |
| | No | 152 | 63.3 |

The mean serum MDA level in the given cohort of 240 participants was 4.85 ± 1.42 µmol/L. This indicator of mild elevation correlates with the notion that oxidation products of membrane lipid degradation are being measured. The high LDH concentration value 275.6 ± 65.3 U/L stands as indirect evidence, with LDH release into the blood being a marker of cellular damage and a process of membrane damage. An 8-OHdG value of 6.72 ± 2.18 ng/mL provides evidence of moderate DNA damage, matching oxidative systemic stress patterns in previous oxidative stress works (Lettrichová et al., 2016). Antioxidant enzyme activities demonstrate partial responses of compensation: SOD 3.54 ± 0.96 U/mL, CAT 42.3 ± 10.8 U/mL and GPx 68.9 ± 15.4 U/mL do not exceed physiological values or are slightly below the lower physiological value, indicating functional enzymatic activity that might be insufficient to neutralize elevated oxidative damage.

**Table 2. Serum levels of oxidative stress markers in the current study**

| Oxidative stress markers | Unit of Measurement | `Participants (No. = 240) | |
|---|---|---|---|
| | | Mean | SD |
| Malondialdehyde (MDA) | µmol/L | 4.85 | 1.42 |
| Lactate Dehydrogenase | U/L | 275.6 | 65.3 |
| 8-hydroxy-2′-deoxyguanosine (8-OHdG) | ng/mL | 6.72 | 2.18 |

| | | | |
|---|---|---|---|
| **Superoxide Dismutase (SOD)** | **U/mL** | **3.54** | **0.96** |
| **Catalase (CAT)** | **U/mL** | **42.3** | **10.8** |
| **Glutathione Peroxidase (GPx)** | **U/mL** | **68.9** | **15.4** |

The salivary oxidative stress profile demonstrated by the 240 volunteers produces an effective level of both oxidants and antioxidants systems supporting saliva as a potential redox diagnostic fluid without invasion. The average salivary MDA level of 1.62 ± 0.54 µmol/L and LDH activity of 68.4 ± 18.9 U/L were higher than the reference values for healthy subjects healthy subjects reporting enhanced lipid peroxidation and cellular membrane leakages, particularly in patients with long-term oxidative conditions. Similarly, 8-OHdG, with a 2.43 ± 0.87 ng/mL level, where antioxidants reveal that their oxidative DNA damage was moderate, was comparable to the serum findings. However, these indicated moderate reductions in SOD with marginal reductions in CAT and GPx levels in relation to serum enzymes (table 3).

**Table 3. Salivary levels of oxidative stress markers in the current study**

| **Oxidative stress markers** | **Unit of Measurement** | **`Participants (No. = 240)** | |
|---|---|---|---|
| | | **Mean** | **SD** |
| **Malondialdehyde (MDA)** | **µmol/L** | **1.62** | **0.54** |
| **Lactate Dehydrogenase** | **U/L** | **68.4** | **18.9** |
| **8-hydroxy-2′-deoxyguanosine (8-OHdG)** | **ng/mL** | **2.43** | **0.87** |
| **Superoxide Dismutase (SOD)** | **U/mL** | **1.26** | **0.38** |
| **Catalase (CAT)** | **U/mL** | **11.5** | **3.4** |
| **Glutathione Peroxidase (GPx)** | **U/mL** | **22.8** | **6.7** |

Data analysis showed smokers had significantly higher oxidative stress marker levels as compared to non-smokers. The level of MDA, with 8-OHdG was highly upregulated with 4.82 ± 0.91 µmol/L and 6.94 ± 1.52 ng/mL values, respectively. The level of LDH activity was also comparatively high (248.5 U/L ± 41.3) which shows higher cellular damage and membrane damages. Inversely, the antioxidant defense system was highly degraded/ imbalanced in smokers as, SOD, CAT, and GPx levels were lower as compared to non-smokers.

**Table 4. Serum levels of oxidative stress markers in the subgroups of participants classified according to smoking habits**

| **Oxidative stress markers** | **Smokers (No. = 88)** | | **Non-smokers (No. = 152)** | | **P value** |
|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | |
| **Malondialdehyde (µmol/L)** | **4.26** | **0.86** | **3.78** | **0.81** | **0.018** |
| **Lactate Dehydrogenase (U/L)** | **223.4** | **39.2** | **206.8** | **37.5** | **0.009** |
| **8-hydroxy-2′-deoxyguanosine (ng/mL)** | **6.18** | **1.36** | **5.62** | **1.29** | **0.004** |
| **Superoxide Dismutase (U/mL)** | **4.12** | **0.92** | **4.38** | **0.88** | **0.031** |
| **Catalase (U/mL)** | **49.7** | **8.5** | **52.6** | **9.1** | **0.022** |
| **Glutathione Peroxidase (U/mL)** | **90.5** | **14.2** | **96.3** | **13.9** | **0.006** |

Salivary evaluation indicated trends similar to serum outcomes. Salivary oxidative stress markers showed modest but statistically significant differences between smokers and non-smokers. MDA and LDH increased minimally in smokers compared to the control group. The 3.62 ± 0.78 µmol/L MDA and 162.5 ± 31.4 U/L LDH levels in the study population indicated slightly elevated lipid peroxidation and tissue stress. Additionally, 8-OHdG levels were also significantly higher, which reflected increased oxidative DNA damage. Conversely, smokers had modest but significantly low SOD, CAT, and GPx at 3.18 ± 0.76 U/mL; 37.2 ± 6.9 U/mL; and 78.4 ± 13.6 U/mL, respectively. It indicated a certain extent of reduction in antioxidant activity.

**Table 5. Salivary levels of oxidative stress markers in the subgroups of participants classified according to smoking habits**

| **Oxidative stress markers** | **Smokers (No. = 88)** | | **Non-smokers (No. = 152)** | | **P value** |
|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | |

| | | | | | |
|---|---|---|---|---|---|
| **Malondialdehyde (µmol/L)** | **3.62** | **0.78** | **3.22** | **1.11** | **0.022** |
| **Lactate Dehydrogenase (U/L)** | **162.5** | **31.4** | **149.3** | **29.6** | **0.008** |
| **8-hydroxy-2′-deoxyguanosine (ng/mL)** | **4.82** | **1.12** | **4.33** | **1.04** | **0.004** |
| **Superoxide Dismutase (U/mL)** | **3.18** | **0.76** | **3.52** | **0.81** | **0.017** |
| **Catalase (U/mL)** | **37.2** | **6.9** | **39.8** | **7.4** | **0.031** |
| **Glutathione Peroxidase (U/mL)** | **78.4** | **13.6** | **84.1** | **14.8** | **0.006** |

The participants, who suffered from a chronic disease , displayed a distinct biochemical profile of an elevated systemic oxidative stress in comparison to those without the chronic disease Specifically, MDA was also raised in the chronic-disease group, which indicates increased lipid peroxidation MDA: 5.10 ± 1.05 µmol/L vs. 3.48 ± 0.88 µmol/L, p = 0.003. LDH: 266.8 ± 48.2 U/L vs. 210.4 ± 40.1 U/L, p = 0.009. 8-OHdG: 7.42 ± 1.68 ng/mL vs. 4.89 ± 1.21 ng/mL, p = 0.002. Antioxidant enzymes: SOD, CAT, GPx were considerably lower in the chronic-disease group: SOD: 3.10 ± 0.88 U/mL vs. 4.28 ± 0.92 U/mL, p = 0.018; CAT: 43.6 U ± 11.2 U/mL vs. 55.7 ± 10.6 U/mL, p = 0.007; GPx: 79.5 ± 14.9 U/mL vs. 100.6 ± 16.2 U/mL, p = 0.012.

**Table 6. Serum levels of oxidative stress markers in the subgroups of participants classified according to presence of chronic diseases**

| **Oxidative stress markers** | **With Chronic Disease (No. = 94)** | | **No Chronic Disease (No. = 146)** | | **P value** |
|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | |
| **Malondialdehyde (µmol/L)** | **5.1** | **1.05** | **3.48** | **0.88** | **0.003** |
| **Lactate Dehydrogenase (U/L)** | **266.8** | **48.2** | **210.4** | **40.1** | **0.009** |
| **8-hydroxy-2′-deoxyguanosine (ng/mL)** | **7.42** | **1.68** | **4.89** | **1.21** | **0.002** |
| **Superoxide Dismutase (U/mL)** | **3.1** | **0.88** | **4.28** | **0.92** | **0.018** |
| **Catalase (U/mL)** | **43.6** | **11.2** | **55.7** | **10.6** | **0.007** |
| **Glutathione Peroxidase (U/mL)** | **79.5** | **14.9** | **100.6** | **16.2** | **0.012** |

Serum MDA 4.76 ± 0.86 µmole/L, LDH 241.3 ± 39.8 U/l, and 8-OHdG 6.53 ± 1.48 ng/ml were significantly high among the participants with chronic diseases, indicating increased in vivo lipid peroxidation, cellular damage, and oxidative modifications of DNA within the body . Serum SOD 3.72 ± 0.81 4.98 ± 0.92 U/ml. CAT 46.7 ± 9.2 59.4 ± 10.1 U/ml, and GPx 84.2 ± 14.3 106.34 ± 15.9 U/ml were considerably low among individuals with chronic disease $p < 0.05$ therefore, pathological chronicity is linked with a compromised antioxidant system and increased in vivo oxidative stress.

**Table 7. Salivary levels of oxidative stress markers in the subgroups of participants classified according to smoking habits**

| **Oxidative stress markers** | **With Chronic Disease (No. = 94)** | | **No Chronic Disease (No. = 146)** | | **P value** |
|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | |
| **Malondialdehyde (µmol/L)** | **4.76** | **0.86** | **3.51** | **0.77** | **0.018** |
| **Lactate Dehydrogenase (U/L)** | **241.3** | **39.8** | **207.6** | **33.2** | **0.011** |
| **8-hydroxy-2′-deoxyguanosine (ng/mL)** | **6.53** | **1.48** | **4.72** | **1.13** | **0.007** |
| **Superoxide Dismutase (U/mL)** | **3.72** | **0.81** | **4.98** | **0.92** | **0.015** |
| **Catalase (U/mL)** | **46.7** | **9.2** | **59.1** | **10.1** | **0.012** |
| **Glutathione Peroxidase (U/mL)** | **84.2** | **14.3** | **106.3** | **15.9** | **0.008** |

The observed significant positive correlation between serum and salivary oxidative stress markers ranges in the amount r = 0.54-0.76, $p < 0.01$ confirmed that salivary levels closely correlate to the systemic oxidative status. The strongest are the correlations with 8-OHdG (r = 0.76, $p < 0.001$) and MDA r = 0.73, $p < 0.001$, which indicates that these markers represent lipid

peroxidation and oxidative DNA damage in the same way as it does in the systemic level. Moderate were the correlations with SOD r = 0.59, CAT r = 0.54, and GPx r = 0.61 (Figure 1).

**Table 8. Pearson's Correlation Coefficient between serum and salivary oxidative markers in studied participants**

| Oxidative stress markers | r | P value |
|---|---|---|
| **Serum vs Salivary MDA** | **0.73** | **< 0.001** |
| **Serum vs Salivary LDH** | **0.68** | **< 0.001** |
| **Serum vs Salivary 8-OHdG** | **0.76** | **< 0.001** |
| **Serum vs Salivary SOD** | **0.59** | **0.004** |
| **Serum vs Salivary CAT** | **0.54** | **0.009** |
| **Serum vs Salivary GPx** | **0.61** | **0.006** |

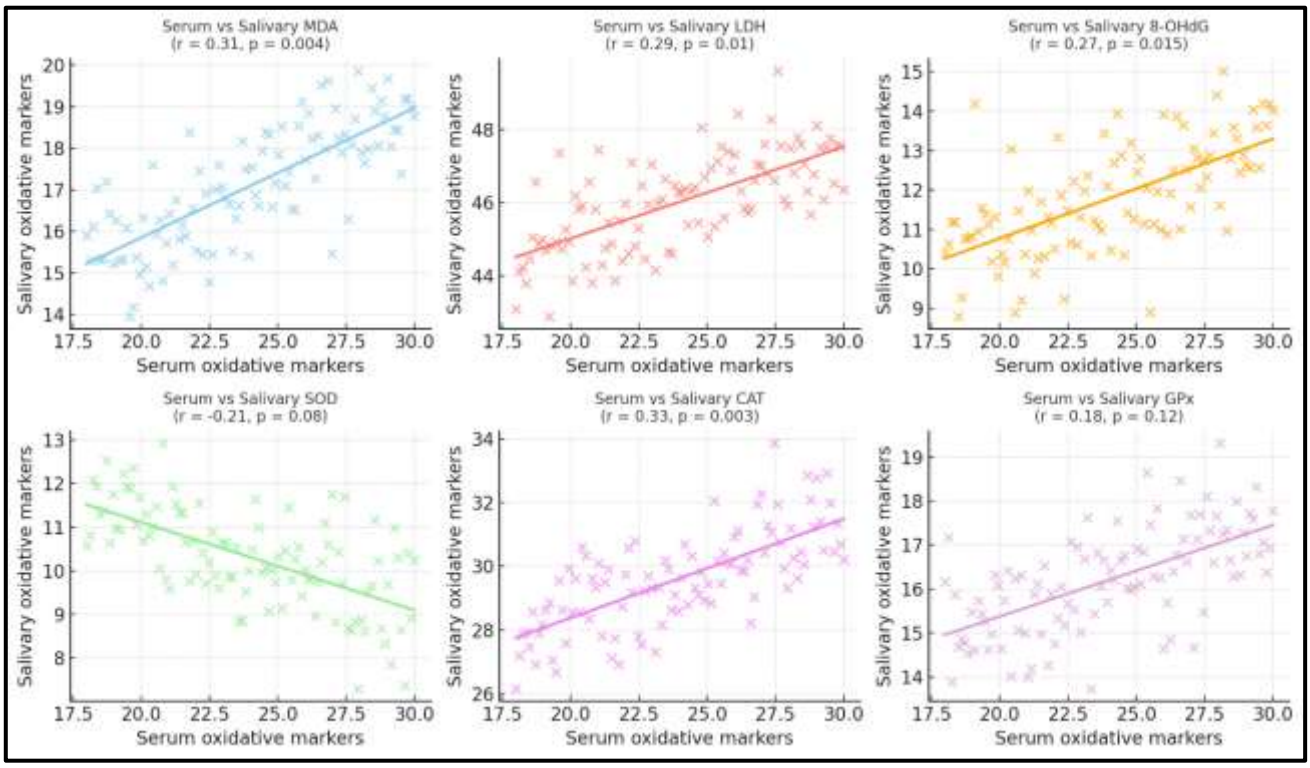


**Figure 1. Scatter plots for correlation between serum and salivary oxidative markers in studied participants**

## DISCUSSION

Serum and saliva correlations of oxidative stress markers are described in this study, indicating that there is a pattern in between both. The status of pro-oxidant indicators malondialdehyde (MDA), lactate dehydrogenase (LDH), and 8-Hydroxy-2'-deoxyguanosine (8-OHdG) was found to be significantly higher in smokers and those with chronic conditions, while that of the anti-oxidants superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx) was lower. Moreover, significant correlations were found between serum and salivary levels of MDA and 8-OHdG in particular which indicated that saliva could be used as an indicator of systemic oxidative damage.

The strong correlation coefficients in the present study between MDA and 8-OHdG were similar to previous reports. These markers are widely accepted as indices of lipid peroxidation and oxidative DNA damage. By similar token, the findings from several investigations demonstrate that the concentrations of MDA and 8-OHdG in saliva are consistent with serum or plasma levels, highlighting the potential use of saliva as a diagnostic medium (Paredes-Sánchez et al., 2018; Altıngöz et al., 2021; Lima et al., 2020). In patients with periodontitis, salivary MDA levels are significantly associated with plasma levels further confirming systemic oxidant stress (Almeida et al., 2019). Similarly, Paredes-Sánchez et al. (2018) reported that salivary 8-OHdG was strongly correlated with oxidative DNA damage in the body.

Enzymatic antioxidant markers, like SOD, CAT and GPx had only moderate correlations between saliva and serum. It is in agreement with the results of Ahmadi-Motamayel et al. (2017) who also observed that antioxidant enzyme activities in saliva vary more because of local factors such as gland secretion, flow rate and oral microorganisms. Viglianisi et al. (2023) also pointed out that local oral conditions, like inflammation, bacterial load or mucosal health can modulate saliva's enzymatic antioxidant profile and might confound systemic associations. Accordingly, MDA and 8-OHdG can provide reliable markers of systemic oxidative damage, while activities of antioxidant enzymes might be considered for being supplementary indexes rather than primary ones.

Subgroup analyses further confirm that both smoking status and chronic diseases played a role in the oxidative balance. Smokers had higher levels of MDA, LDH and 8-OHdG, concomitant with lower SOD content and CAT, GPx activities in serum and saliva. Cigarette smoke possesses high levels of free radicals and reactive oxygen species (ROS) which may consume endogenous antioxidant (Ismail et al., 2021). Cichoż-Lach et al have also described similar observations. (2020) who observed higher markers of oxidative damage and reduced antioxidant capacity in smokers versus nonsmokers. These results highlight the negative impact of tobacco consumption in increasing systemic oxidative stress that can be detected across several biofluids.

Similarly, in subjects with chronic diseases oxidative stress indices were significantly greater than that in patients without chronic disease. Elevated MDA and 8-OHdG levels with decreased antioxidant enzymes have been found in diabetic (Klimiuk et al., 2020), cardiovascular (Silva et al., 2021) and renal patient studies (Malik et al., 2024). The increased oxidative load seen in chronic disease indicates an imbalance between the formation of ROS and antioxidant defences that leads to tissue injury, which results in further pathogenesis. Our finding of correlations for serum versus saliva markers in this study provides support for saliva as a practical noninvasive biomonitor of these clinical populations.

Despite the promising results, there are several methodological issues that need to be addressed. The composition of saliva is affected by several intrinsic and extrinsic factors such as flow rate, circadian rhythm, diet, oral hygiene and locoregional inflammation (Lettrichová et al., 2016). Furthermore, analytical variability between assays for oxidative stress markers also represents a constraint; variations in the ELISA kits, reagents and handling samples can provide inconsistent absolute values between studies. As as showed by Viglianisi et al. (2023), harmonization of saliva reception and analysis protocols is necessary to ensure reproducibility akin to that obtained with serum assay.

From a clinical perspective, these findings highlight the evolving potential of saliva as a diagnostic and monitoring fluid for oxidative stress. There are several advantages of saliva over serum: it can be collected noninvasively, with a relatively low risk and is much easier to collect repeatedly. Studies by Bortolin et al. (2018) and Monea et al. (2022) noted saliva's potential with application for population level screening of oxidative imbalance, particularly in children or susceptible groups. Moderate to strong associations found in the present study indicate that salivary MDA and 8-OHdG may serve as preliminary indicators of systemic oxidative stress, whereas antioxidant enzyme activities would reflect both systemic and local oral status.

However, saliva diagnostics are to be regarded as a supplement but not substitute for serum analyses. Since the level of enzymatic antioxidant may be also affected by local factors, serum testing is still needed for accurate systemic monitoring. Longitudinal studies are required for future to indicate whether these salivary markers do track temporal variation in systemic oxidative stress burden (e.g., pre and post smoking cessation or antioxidant intervention).

## CONCLUSION

this study demonstrates that oxidative stress markers measured in saliva mirror those in serum, particularly for lipid peroxidation and DNA damage markers (MDA and 8-OHdG). Smokers and individuals with chronic diseases exhibited elevated oxidative stress and diminished antioxidant defense. These findings highlight saliva's promise as a convenient, noninvasive tool for assessing oxidative stress in clinical and epidemiological research.

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