MedPharmRes

Journal of University of Medicine and Pharmacy at Ho Chi Minh City
homepage: http://www.medpharmres.vn/ and http://www.medpharmres.com/

Original article

Total oxidant status and total antioxidant capacity in the saliva of patients with chronic periodontitis

Thuy Thu Nguyen[a], Duc Anh Vo[b], Truc Thanh Thai[c], Thuy Lam Vo[d], Nam Cong Nhat Huynh[e*]

[a]*Department of Periodontology, Faculty of Odonto-stomatology, University of Medicine and Pharmacy at Ho Chi Minh City, Ho Chi Minh City, Vietnam;*
[b]*Nhan Tam Dental Clinic, Ho Chi Minh City, Vietnam;*
[c]*Department of Medical Statistics and Informatics, Faculty of Public Health, University of Medicine and Pharmacy at Ho Chi Minh City, Ho Chi Minh City, Vietnam;*
[d]*Department of Implantology, Faculty of Odonto-stomatology, University of Medicine and Pharmacy at Ho Chi Minh City, Ho Chi Minh City, Vietnam;*
[e]*Department of Dental Basic Sciences, Faculty of Odonto-stomatology, University of Medicine and Pharmacy at Ho Chi Minh City, Ho Chi Minh City, Vietnam.*

Received July 09, 2020: Revised August 27, 2020: Accepted September 17, 2020

Abstract: ***Background:*** Recently, methods of quantifying total oxidant status (TOS) and total antioxidant capacity (TAOC) were developed to investigate periodontitis. This study was performed to evaluate the salivary TOS and TAOC levels of patients with chronic periodontitis (CP) and investigating the association between periodontal clinical parameters and these oxidative stress biomarkers. ***Material and methods:*** 40 participants (23-65 years old) were classified into two groups of 20 each, namely the CP group (participants with CP) and the control group (periodontally healthy controls). Clinical periodontal parameters were monitored, and TOS and TAOC levels were measured using laboratory assays. ***Results:*** TOS level increased in the saliva of patients with CP and the salivary TAOC in patients with CP was significantly lower than that of the control group. The TOS had a positive moderate correlation with the plaque index and clinical attachment loss (r=0.32 and 0.37, respectively) while TAOC was negatively and moderately correlated with clinical attachment loss (r=-0.35). ***Conclusion:*** Salivary TOS and TAOC were distinguished in healthy and chronic PD patients. Further studies are required to comprehensively evaluate the potential role of these biomarkers in diagnosis and treatment evaluation of CP.

Keywords: saliva; chronic periodontitis; oxidative stress.

1. INTRODUCTION

Chronic periodontitis (CP) is a destructive form of periodontal diseases (PD), and has been suggested to augment the risks of certain systemic diseases [1]. The common clinical indicators used in the diagnosis of PD are the periodontal pocket depth (PPD), the bleeding on probing index (BOP), the clinical attachment loss (AL) and analysis on X-ray film [2]. These factors are meant to indicate the severity of PD, while their role in predicting the PD is quite poor [3]. Therefore, the search for other indicators in support of diagnosis and prediction is ongoing.

*Address correspondence to Nam Cong-Nhat Huynh at Department of Dental Basic Sciences, Faculty of Odonto-Stomatology, University of Medicine and Pharmacy at Ho Chi Minh City, Vietnam; Tel/Fax: (+84-28) 3855 8735 - 3855 2641, (+84-28) 3855 2300; E-mails: namhuynh@ump.edu.vn
DOI: 10.32895/UMP.MPR.4.4.4

Recently, reactive oxidant species (ROS) have been suggested to be associated with the development of periodontitis. ROS is a phrase used to depict a group of free oxygen radicals and chemical reactive molecules that are oxidizing agents and/or easily converted into radicals [4]. Oxidative stress (OS) occurs when the balance between free radicals and cellular antioxidants is impaired, resulting from the overproduction and/or mismanagement of ROS, loss of antioxidant defense, or both [5]. A previous study has shown that patients with periodontitis had an increase in lipid, protein and DNA oxidation products [6]. As an alternative to the quantification of oxidation products, a method of quantifying total oxidant status (TOS) was developed by Erel in 2005 [7]. Otherwise, oxidative factors that occur during inflammation are neutralized by various antioxidant systems. Therefore, the quantification of total antioxidant capacity (TAOC) could be considered as an important tool in the diagnosis of PD.

In order to better understand the role of related biomarkers in the diagnosis of PD, we conducted this study in aiming at evaluating the TOS and TAOC levels in the saliva of patients with CP compared to that of the control group and investigating the possible relationship between periodontal clinical parameters and these OS biomarkers.

2. MATERIALS AND METHOD

2.1. Patients and study design

40 participants (17 men and 23 women, aged from 23 to 65 years old) were enrolled in this case-control study, from May 2018 to June 2019, at the Faculty of Odonto-stomatology, University of Medicine and Pharmacy at Ho Chi Minh City. Among these, 20 patients had CP (the CP group), and 20 patients had periodontally healthy controls (the control group). The sample size was calculated based on the results of previous studies [8, 9]. Data about dental health behaviors, smoking habits, educational backgrounds, socioeconomic status and the presence of systemic diseases were collected with questionnaire (Supplementary Document S1). The eligibility criteria for participants were described in our previous studies [10, 11]. The inclusion criteria were as follows: 1/ no systemic disease; 2/ no periodontal treatment within six months from the enrollment date; 3/ no antibiotic, anti-inflammatory, or antioxidant medication within three months from the enrollment date; 4/ non-smokers; 5/ no diabetes or hypertension; 6/ no alcohol consumption; 7/ no menstruation, pregnancy, or lactation at the time of the study; 8/ a body mass index (BMI) of less than 25; 9/ age from 21 years old; 10/ more than 18 teeth present; 11/ less than 5 decay cavities, and 12/ no hypo- or hyper-salivation.

The patients were clinically and radiographically evaluated for generalized CP according to the 1999 International Workshop for a Classification of Periodontal Diseases criteria [12, 13]. The bone loss conditions were verified through a panoramic radiograph of each patient. Subjects were recruited to the CP group when satisfying the following criteria: PPD > 3 mm, positive BOP index, AL ≥ 2 mm and >15% of sites with bone loss or presence of sites with bone loss ≥ 2 mm. The control group had clinically healthy gingiva with the scores of gingival indices (GI), PPD, and plaque index (PI) being less than 1 mm, 2 mm, and 1 mm, respectively.

The Ethics Committee of the University of Medicine and Pharmacy at Ho Chi Minh City approved the study protocol (No.18327/DHYD-HD). All participants signed informed consent before enrollment.

2.2. Periodontal clinical parameters

PI, GI, BOP, PPD, and AL were used as the periodontal clinical parameters in the study. Six positions (mesio-buccal, buccal, disto-buccal, mesio-lingual, lingual, and disto-lingual) and full-mouth measurements were performed. The values of each parameter (PI, GI, PPD and AL) were calculated by dividing the total score to the number of positions. The final BOP index was presented by the percentage of sites where bleeding had been recorded. The same clinician carried out this process using a Williams periodontal probe (Hu-Friedy, Chicago, IL, USA). The inter-rater reliability assessment was conducted as follows: five participants had their periodontal parameters for five teeth measured by the rater on a continuous scale; then under the same condition, the measurement was repeated for the same participants an hour after the first test. Then, the Interclass Correlation Coefficient (ICC) was determined. The ICC showed values of 0.85, 0.79, 0.80, 0.82, and 0.89 for PI, GI, BOP, PPD, and AL, respectively.

2.3. Saliva collection

The whole unstimulated saliva was collected using the standard technique described by Navazesh et al [14]. 5 mL of saliva was collected, and the time collecting the sample was recorded. The salivary flow rate (SFR) was determined by the volume of saliva collected in one minute. Samples were then centrifuged at 3,000 rpm for 10 minutes at 4 °C to remove debris and cells. The supernatant was divided into small aliquots and immediately stored at -80 °C until assays were performed.

2.4. TOS and TAOC assays

TAOC and TOS were quantified using TAOC (Total Antioxidant Capacity Assay Kit, Sigma Aldrich®, Missouri, USA) and TOS (Total Oxidant Status Assay Kit, Creative Diagnostics®, New York, USA) kits according to the manufacturer's instructions.

2.5. Data analysis

For statistical analysis, the difference between CP and control group was compared by Chi-square test and Wilcoxon ranksum tests with the level of significance being 0.05. The correlation between clinical and laboratory parameters was determined by Spearman correlation coefficients and its significance tests. Ordinary Least Squares regression (OLS) was used to assess the magnitude of association between clinical parameters and TOS, TAOC for each study group with adjustment for age and sex.

3. RESULTS

There were 40 patients recruited in the study, including 20 in the CP group (mean age, 47,05 ±9,68 years; 11 men and 9 women) and 20 in the control group (mean age, 23,6±1,14 years; 6 men and 14 women) (Figure 1). There was no significant difference in sex distribution between the study

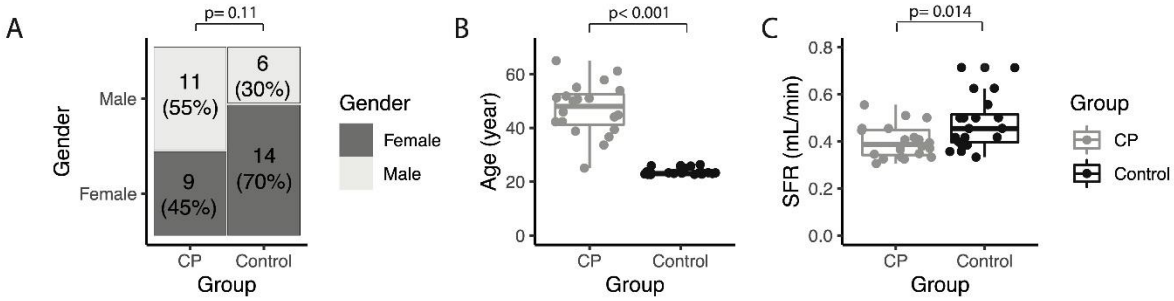

Figure 1: Gender, age and the saliva flow rate (SFR) of study groups.

A. There was no significant difference in genders between chronic periodontitis (CP) and control group (Chi-square test). B Control group was younger than CP group significantly (Wilcoxon ranksum test). C. SFR in CP group was lower than in control significantly (Wilcoxon ranksum test).

groups (p=0.110). However, significant differences in age and SFR were found between the study groups (p<0.001).

Periodontal clinical parameters

The periodontal parameters are presented in Table 1. The results showed that all the periodontal clinical parameters including PI, GI, BOP, PPD and AL were significantly higher in the CP group than control group (p<0.001).

Table 1: Periodontal **parameters and saliva flow rate of the study groups.**

	Total	**CP group**	**Control group**	**p[a]**
PI				
Mean±SD	0.67±0.65	1.17±0.51	0.16±0.26	<0.001
Median Interquartile range	0.5 (0 - 1.23)	1.23 (0.78 - 1.56)	0 (0 - 0.22)	
GI				
Mean±SD	0.72±0.69	1.3±0.43	0.14±0.3	<0.001
Median Interquartile range	0.59 (0 - 1.33)	1.33 (1.03 - 1.55)	0 (0 - 0.15)	
BOP (%)				
Mean±SD	31.73±36.86	59.65±33.62	3.8±4.1	<0.001
Median Interquartile range	9.5 (2.5 – 66)	66 (27 – 92)	2.5 (0 – 7)	
PPD (mm)				
Mean±SD	1.75±1.45	3.05±0.61	0.45±0.62	<0.001
Median Interquartile range	2.09 (0.2 - 2.91)	2.91 (2.68 - 3.54)	0.2 (0 - 0.96)	
AL (mm)				
Mean±SD	2.23±1.82	3.76±1.02	0.7±0.88	<0.001
Median Interquartile range	2.55 (0.33 - 3.46)	3.46 (2.85 - 4.54)	0.35 (0 - 1.48)	

[a]Wilcoxon ranksum tests

TOS and TAOC levels

The results showed that the TOS level in the CP group was significantly higher than the control group (p=0.020). The TAOC level in the CP group was significantly lower than the control group (p<0.001). These results are presented in Table 2.

The correlations between periodontal clinical parameters and OS biomarkers

The correlations among variables are shown in Table 3. There were significantly positive correlations between salivary TOS levels and PI (r = 0.32; p = 0.045) and CAL values (r = 0.35; p = 0.019) and significantly moderate negative correlation between salivary TAOC levels and AL values (r = -0.35; p = 0.028). Other correlations were not statistically significant (p > 0.05).

Table 4 presents the association between clinical parameters and TOS, TAOC for each study group with adjustment for age and sex. The results showed that there were significant correlations between salivary TOS levels and PPD (p = 0.002) and AL values (p < 0.001). TAOC level was significantly correlated with PI (p = 0.014) and GI values (p = 0.029).

Table 2: Total oxidant status (TOS) and total antioxidant capacity (TAOC) of the study groups.

	Total	CP group	Control group	p[a]
TOS (μM H_2O_2/L)				
Mean±SD	3.85±3.59	5.10±4.15	2.60±2.47	0.020
Median Interquartile range	2.41 (1.06 - 6.17)	3.74 (1.37- 9.67)	1.96 (0.73 - 3.6)	
Min-Max	0.14 - 12.31	0.14 - 12.3	0.39 - 9.08	
TAOC (mM)				
Mean±SD	1.51±0.75	1.21±0.64	1.81±0.74	<0.001
Median Interquartile range	1.4 (0.9 - 2.04)	0.92 (0.77 -1.81)	1.62 (1.37 - 2.19)	
Min-Max	0.36 - 3.67	0.36 - 2.66	0.42 - 3.66	

[a] Wilcoxon ranksum test

Table 3: Correlations between periodontal parameters and TOS, TAOC

		PI	GI	BOP	PPD	AL	SFR	TOS
GI	**R**	0.96						
	(*p*)	(<0.001)						
BOP (%)	**R**	0.88	0.89					
	(*p*)	(<0.001)	(<0.001)					
PPD (mm)	**R**	0.90	0.89	0.86				
	(*p*)	(<0.001)	(<0.001)	(<0.001)				
AL (mm)	**R**	0.90	0.88	0.88	0.98			
	(*p*)	(<0.001)	(<0.001)	(<0.001)	(<0.001)			
SFR	**R**	0.37	0.43	0.29	0.25	0.27		
(ml/p)	**(*p*)**	(0.018)	(0.005)	(0.069)	(0.114)	(0.096)		
TOS	**R**	0.32	0.30 (0.61)	0.31	0.34 (0.32)	0.37	-0.11	
	(*p*)	(0.045)		(0.059)		(0.019)	(0.496)	
TAOC	**R**	-0.16	-0.21	-0.24	-0.31	-0.35	-0.27	0.38
	(*p*)	(0.322)	(0.184)	(0.138)	(0.052)	(0.028)	(0.087)	(0.815)

Note: R = Spearman's correlation coefficient, p = p value from significance test

Table 4: Correlations between periodontal parameters and TOS, TAOC stratified by study groups with adjustment for age and sex

	TOS		TAOC	
	Coef (95% CI)	**p**	**Coef (95% CI)**	**p**
PI				
All	2.66 (0.34; 4.98)	0.026	0.50 (0.08; 0.93)	0.022
CP	3.07 (-0.77; 6.91)	0.110	0.62 (0.14; 1.09)	0.014
Control	-2.04 (-7.38; 3.30)	0.430	0.35 (-0.88; 1.58)	0.555
GI				
All	2.28 (-0.19; 4.75)	0.069	0.39 (-0.07; 0.85)	0.093

	TOS		TAOC	
	Coef (95% CI)	**p**	**Coef (95% CI)**	**p**
CP	3.38 (-1.34; 8.10)	0.149	0.68 (0.08; 1.28)	0.029
Control	-1.78 (-6.19; 2.63)	0.405	0.28 (-0.74; 1.30)	0.570
BOP (%)				
All	0.05 (0.01; 0.09)	0.013	0.01 (-0.01; 0.01)	0.194
CP	0.05 (-0.01; 0.10)	0.111	0.01 (-0.01; 0.01)	0.322
Control	-0.13 (-0.46; 0.20)	0.408	0.02 (-0.06; 0.09)	0.625
PPD (mm)				
All	1.98 (0.72; 3.23)	0.003	0.20 (-0.05; 0.46)	0.112
CP	4.74 (2.03; 7.46)	0.002	0.17 (-0.33; 0.67)	0.481
Control	-0.42 (-2.71; 1.87)	0.703	0.05 (-0.47; 0.58)	0.833
AL (mm)				
All	1.55 (0.65; 2.44)	0.001	0.12 (-0.06; 0.31)	0.188
CP	3.00 (1.56; 4.45)	<0.001	0.07 (-0.23; 0.36)	0.639
Control	-0.58 (-2.14; 0.97)	0.438	0.03 (-0.33; 0.39)	0.851
SFR (ml/p)				
All	7.08 (-4.84; 18.99)	0.236	1.19 (-1.02; 3.40)	0.283
CP	15.18 (-16.33; 46.70)	0.322	-0.18 (-4.68; 4.32)	0.933
Control	7.59 (-3.20; 18.37)	0.155	1.79 (-0.66; 4.24)	0.142

4. DISCUSSION

In our study, the age of the two groups was different significantly; this observation could be explained by the characteristics of PD which is common in elderly population [15]. The difference in the age of the two groups in this study is also consistent with previous similar studies [16, 17].

On the other hand, the mean SFR values in the control group were significantly higher than in the CP group. The average values in the two groups of this study were almost similar to those of Wei et al. [8]. However, this result was inconsistent with the previous study by Nguyen et al. [10, 11]. The inconsistency between studies could be explained by the fact that SFR is influenced by many factors such as individual's characteristics and methods of determining SFR.

The mean of TOS values in saliva of CP patients was almost two times higher than that of the control group. This result was similar to previous studies [8, 18] where increased TOS was observed in periodontitis. The increase of TOS level in saliva reflects the increase of ROS radicals in PD. A study using TOS as an indicator to track the effectiveness of non-surgical periodontal treatment showed that TOS had a statistically significant reduction after good treatment of PD [8].

The salivary TAOC in patients with CP was significantly lower than that of the control group. The results of this study were similar to previous studies on TAOC in saliva of PD patients [19-21]. This can be explained by the fact that the immune system's inactivity against the periodontal pathogens leads to an increase in ROS products from neutrophilic granulocytes. To counteract the tissue destruction of ROS, a large amount of antioxidant components must be used to neutralize the ROS, which is probably the cause of the decrease in TAOC concentration in saliva in patients with PD.

However, several studies revealed that TAOC increased or remained unchanged between PD group and control group [22, 23]. Differences in salivary TAOC levels in different studies can be explained by the diversity of TAOC measurement methods. In addition, TAOC is a complex variable since it is the synthesis of the antioxidant capacity of many different substances; so it will depend on the interaction and synergistic effects between these substances [24].

The TOS has a positive moderate correlation with the PI and AL (or PPD and AL after age and sex adjustment). This suggests that the TOS has the potential to replace clinical periodontal indicators in monitoring disease severity or assessing treatment effectiveness. In previous studies,[8, 18] TOS was strongly associated with clinical periodontal indicators. However, Zhang et al. concluded that TOS was not associated with any clinical periodontal index [21]. Further research on the use of TOS as a replacement for periodontal indices should be conducted with better control of interfering factors that may affect oxidative stress such as eating regimen and smoking status. TAOC is negatively and moderately correlated with AL (or PI and GI after age and sex adjustment). Further research is in need to confirm that TAOC is related to the severity of the disease.

The limits of this current study were that data on systemic diseases were collected based on questionnaires and we did not investigate much on factors that may have effects on both PD and oxidative stress such as lifestyle or oral hygiene. Furthermore, small simple size, non-randomized study design and a lack of blinding of examiners may also be considered as major limits to interpret data to the full meanings. Otherwise, the difference in age between the two study groups could lead to bias in results; which should be corrected in further studies.

Conclusion

In this current study, we found that TOS level increased in the saliva of patients with CP and the salivary TAOC in patients with CP was significantly lower than that of the control group. The TOS has a positive moderate correlation

with the PI and AL while TAOC is negatively and moderately correlated with AL. Future studies are necessary to thoroughly evaluate the potential role of TOS and TAOC in diagnosis and treatment evaluation of PD.

ACKNOWLEDGEMENTS

The authors would like to thank the Colgate Palmolive (Vietnam) Limited Company for their contribution in supplying participants with oral hygiene devices during the study.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

Supplementary Document S1: Questionnaire for evaluating the medical and dental status of the participants.

ORCID ID

Thuy Thu Nguyen https://orcid.org/0000-0003-2525-2880
Duc Anh Vo https://orcid.org/0000-0002-5199-6165
Truc Thanh Thai https://orcid.org/0000-0003-2512-8281
Thuy Lam Vo https://orcid.org/0000-0002-8106-430X
Nam Cong Nhat Huynh https://orcid.org/0000-0003-4718-7813

REFERENCES

1. Arigbede AO, Babatope BO, Bamidele MK. Periodontitis and systemic diseases: A literature review. Journal of Indian Society of Periodontology. 2012;16(4):487-91. Epub 2013/03/16. doi: 10.4103/0972-124x.106878. PubMed PMID: 23493942; PubMed Central PMCID: PMCPMC3590713.
2. Goodson JM. Clinical measurements of periodontitis. J Clin Periodontol. 1986;13(5):446-60. Epub 1986/05/01. doi: 10.1111/j.1600-051x.1986.tb01489.x. PubMed PMID: 3459739.
3. Lindhe J, Haffajee AD, Socransky SS. Progression of periodontal disease in adult subjects in the absence of periodontal therapy. J Clin Periodontol. 1983;10(4):433-42. Epub 1983/07/01. doi: 10.1111/j.1600-051x.1983.tb01292.x. PubMed PMID: 6577035.
4. Halliwell B, Whiteman M. Measuring reactive species and oxidative damage in vivo and in cell culture: how should you do it and what do the results mean? Br J Pharmacol. 2004;142(2):231-55. Epub 2004/05/25. doi: 10.1038/sj.bjp.0705776. PubMed PMID: 15155533; PubMed Central PMCID: PMCPMC1574951.
5. Dalle-Donne I, Rossi R, Colombo R, Giustarini D, Milzani A. Biomarkers of oxidative damage in human disease. Clinical chemistry. 2006;52(4):601-23. Epub 2006/02/18. doi: 10.1373/clinchem.2005.061408. PubMed PMID: 16484333.
6. Tothova L, Kamodyova N, Cervenka T, Celec P. Salivary markers of oxidative stress in oral diseases. Front Cell Infect Microbiol. 2015;5:73. Epub 2015/11/06. doi: 10.3389/fcimb.2015.00073. PubMed PMID: 26539412; PubMed Central PMCID: PMCPMC4611854.
7. Erel O. A new automated colorimetric method for measuring total oxidant status. Clin Biochem. 2005;38(12):1103-11. Epub 2005/10/11. doi: 10.1016/j.clinbiochem.2005.08.008. PubMed PMID: 16214125.
8. Wei D, Zhang XL, Wang YZ, Yang CX, Chen G. Lipid peroxidation levels, total oxidant status and superoxide dismutase in serum, saliva and gingival crevicular fluid in chronic periodontitis patients before and after periodontal therapy. Aust Dent J. 2010;55(1):70-8. Epub 2010/04/27. doi: 10.1111/j.1834-7819.2009.01123.x. PubMed PMID: 20415915.
9. Novakovic N, Todorovic T, Rakic M, Milinkovic I, Dozic I, Jankovic S, et al. Salivary antioxidants as periodontal biomarkers in evaluation of tissue status and treatment outcome. Journal of periodontal research. 2014;49(1):129-36. Epub 2013/05/29. doi: 10.1111/jre.12088. PubMed PMID: 23710550.
10. Nguyen TT, Ngo LQ, Promsudthi A, Surarit R. Salivary Lipid Peroxidation in Patients With Generalized Chronic Periodontitis and Acute Coronary Syndrome. Journal of periodontology. 2016;87(2):134-41. Epub 2015/08/28. doi: 10.1902/jop.2015.150353. PubMed PMID: 26313018.
11. Nguyen TT, Ngo LQ, Promsudthi A, Surarit R. Salivary oxidative stress biomarkers in chronic periodontitis and acute coronary syndrome. Clin Oral Investig. 2017;21(7):2345-53. Epub 2016/12/18. doi: 10.1007/s00784-016-2029-3. PubMed PMID: 27987039.
12. Armitage GC. Development of a classification system for periodontal diseases and conditions. Ann Periodontol. 1999;4(1):1-6. Epub 2000/06/23. doi: 10.1902/annals.1999.4.1.1. PubMed PMID: 10863370.
13. American Academy of Periodontology Task Force Report on the Update to the 1999 Classification of Periodontal Diseases and Conditions. Journal of periodontology. 2015;86(7):835-8. Epub 2015/07/01. doi: 10.1902/jop.2015.157001. PubMed PMID: 26125117.
14. Navazesh M. Methods for collecting saliva. Annals of the New York Academy of Sciences. 1993;694:72-7. Epub 1993/09/20. doi: 10.1111/j.1749-6632.1993.tb18343.x. PubMed PMID: 8215087.
15. Demetriou N, Parashis A, Tsami-Pandi A. [Relationship between age and clinical symptoms of periodontal disease]. Stomatologia (Athenai). 1990;47(4):231-41. Epub 1990/07/01. PubMed PMID: 2131686.
16. Ghallab NA, Hamdy E, Shaker OG. Malondialdehyde, superoxide dismutase and melatonin levels in gingival crevicular fluid of aggressive and chronic periodontitis patients. Aust Dent J. 2016;61(1):53-61. Epub 2015/01/13. doi: 10.1111/adj.12294. PubMed PMID: 25581300.
17. Miricescu D, Totan A, Calenic B, Mocanu B, Didilescu A, Mohora M, et al. Salivary biomarkers: relationship between oxidative stress and alveolar bone loss in chronic periodontitis. Acta Odontol Scand. 2014;72(1):42-7. Epub 2013/07/23. doi: 10.3109/00016357.2013.795659. PubMed PMID: 23869629.
18. Akalin FA, Baltacioglu E, Alver A, Karabulut E. Lipid peroxidation levels and total oxidant status in serum, saliva and gingival crevicular fluid in patients with chronic periodontitis. J Clin Periodontol. 2007;34(7):558-65. Epub 2007/06/09. doi: 10.1111/j.1600-051X.2007.01091.x. PubMed PMID: 17555410.
19. Diab-Ladki R, Pellat B, Chahine R. Decrease in the total antioxidant activity of saliva in patients with periodontal diseases. Clin Oral Investig. 2003;7(2):103-7. Epub 2003/05/14. doi: 10.1007/s00784-003-0208-5. PubMed PMID: 12743837.
20. Guentsch A, Preshaw PM, Bremer-Streck S, Klinger G, Glockmann E, Sigusch BW. Lipid peroxidation and antioxidant activity in saliva of periodontitis patients: effect of smoking and periodontal treatment. Clin Oral Investig. 2008;12(4):345-52. Epub 2008/05/30. doi: 10.1007/s00784-008-0202-z. PubMed PMID: 18509684.
21. Zhang T, Andrukhov O, Haririan H, Muller-Kern M, Liu S, Liu Z, et al. Total Antioxidant Capacity and Total Oxidant Status in Saliva of Periodontitis Patients in Relation to Bacterial Load. Front Cell Infect Microbiol. 2015;5:97. Epub 2016/01/19. doi: 10.3389/fcimb.2015.00097. PubMed PMID: 26779448; PubMed Central PMCID: PMCPMC4702083.
22. Tothova L, Hodosy J, Mettenburg K, Fabryova H, Wagnerova A, Babickova J, et al. No harmful effect of different Coca-cola beverages after 6 months of intake on rat testes. Food Chem Toxicol. 2013;62:343-8. Epub 2013/09/05. doi: 10.1016/j.fct.2013.08.073. PubMed PMID: 24001441.
23. Almerich-Silla JM, Montiel-Company JM, Pastor S, Serrano F, Puig-Silla M, Dasi F. Oxidative Stress Parameters in Saliva and Its Association with Periodontal Disease and Types of Bacteria. Dis Markers. 2015;2015:653537. Epub 2015/10/27. doi: 10.1155/2015/653537. PubMed PMID: 26494938; PubMed Central PMCID: PMCPMC4606402.
24. Ghiselli A, Serafini M, Natella F, Scaccini C. Total antioxidant capacity as a tool to assess redox status: critical view and experimental data. Free Radic Biol Med. 2000;29(11):1106-14. Epub 2000/12/21. doi: 10.1016/s0891-5849(00)00394-4. PubMed PMID: 11121717.