ORIGINAL ARTICLE

The Effect of Total Antioxidant Capacity on Periodontal Diseases among Ionizing Radiation Workers

Shams Waleed Khalid * , **Ahlam Taha Mohammed**

Department of Pedodontics and preventive dentistry, College of Dentistry, University of Baghdad. Bab-Almoadham, P.O. Box 1417, Baghdad, Iraq

*Corresponding Author: Shams Waleed Khalid
Email: Shams.Waleed1202a@codental.uobaghdad.edu.iq

Received: 15 May 2023 / Accepted: 16 July 2023

Abstract

Purpose: This study aimed to evaluate the effect of total antioxidant capacity on periodontal diseases among ionizing radiation workers. The relationship between oxidative stress and periodontal health in this specific occupational group was assessed to gain insights into potential antioxidant supplementation needs and strategies to promote periodontal well-being.

Materials and Methods: This case-control study was conducted among ionizing radiation workers (CT scan section) and control group participants. Salivary samples were collected from both groups, and total antioxidant capacity was measured using an Enzyme-Linked Immunosorbent Assay (ELISA) kit. Clinical periodontal parameters were also assessed. Statistical analysis was performed using T-tests to compare the results between the groups.

Results: The study group showed a significantly lower total antioxidant capacity (2.534) compared to the control group (3.806) ($p = 0.022$). Significant differences were observed in plaque index, probing pocket depth, and clinical attachment loss between the groups. These findings suggest a potential association between radiation exposure, decreased antioxidant capacity, and periodontal tissue damage.

Conclusion: Radiographic workers exposed to ionizing radiation had lower antioxidant capacity and higher rates of periodontal diseases. Maintaining adequate antioxidants is crucial for protecting periodontal tissues. Further research should investigate mechanisms and exposure variations.

Keywords: Total Antioxidant Capacity; Ionizing Radiation; Periodontal Diseases; Oxidative Stress; Radiographic Workers; Salivary Samples.

DOI: https://doi.org/10.18502/fbt.v11i3.15890

Frontiers in BIOMEDICAL TECHNOLOGIES

1. Introduction

Radiological examinations involving ionizing radiation have been known to initiate free radical reactions in the body [1, 2]. When ionizing radiation interacts with water molecules after passing through the cell membrane, it leads to the formation of oxygen free radicals [3-5]. These free radicals have been associated with oxidative stress, which refers to the damaging effect they exert on biological systems [3, 6]. Oxidative stress can result in harmful effects on DNA, RNA, proteins, and lipids, thereby increasing the risk of various diseases, including cardiovascular disease, cancer, and neurological disorders [7-9].

Periodontitis, a chronic inflammatory disease characterized by the destruction of alveolar bone and connective tissue, is influenced by various factors, including pathogenic bacterial colonization [10, 11]. The inflammatory response triggered by pathogenic bacteria and their associated cell membrane lipopolysaccharides can lead to the production of reactive cells and the release of pro-inflammatory cytokines, contributing to periodontal tissue destruction [12, 13]. During this inflammatory process, oxidants interact with target proteins or are neutralized by the antioxidant system. Consequently, evaluating the total antioxidant capacity in saliva can serve as a valuable diagnostic tool for assessing periodontal health [14-16].

However, the effects of ionizing radiation exposure on periodontal health and the relationship between oxidative stress and antioxidant levels among radiographic workers remain relatively unexplored [17, 18]. Given the potential association between ionizing radiation, oxidative stress, and periodontal diseases, it is crucial to investigate the impact of total antioxidant capacity on periodontal diseases among ionizing radiation workers.

Therefore, this study aims to evaluate the effect of total antioxidant capacity on periodontal diseases among ionizing radiation workers. By assessing the relationship between oxidative stress and periodontal health in this specific occupational group, we can gain insights into the potential need for antioxidant supplementation and identify strategies to promote periodontal well-being among radiographic workers.

This study is significant as it addresses a research gap regarding the specific effects of ionizing radiation and oxidative stress on periodontal diseases. Furthermore, understanding the relationship between total antioxidant capacity and periodontal health among radiographic workers can provide valuable information for developing preventive measures and interventions to mitigate the potential risks associated with occupational radiation exposure.

2. Materials and Methods

This case-control study was conducted from November 2021 to March 2022 in different hospitals located in Baghdad City. Ethical approval for the study protocol was obtained from the ethical committee of the College of Dentistry at the University of Baghdad.

The study group consisted of 40 male participants with a mean ± SD of 5±2 years of occupational experience in the field of ionizing radiation, specifically CT scans, where they typically worked a workload of around 40 hours per week, handled between 8 and 12 cases per shift, and had 8-hour working shifts. The control group comprised 40 male participants employed as workers in the hospital's lab who had not been exposed to ionizing radiation, had no history of systemic illness, and had not taken any antibiotics for at least two weeks.

Salivary samples were collected from each participant under standardized conditions in the early morning (9-11 A.M.). After collection, the samples were placed in a small chilling box to prevent bacterial growth and then transferred to a small cooling box. Subsequently, the saliva samples were centrifuged at 4000 rpm for 15 minutes to obtain clear supernatant, which was collected using a micropipette and transferred into Eppendorf tubes. The samples were stored at -20°C in a freezer until further assessment.

The measurement of total antioxidant capacity was performed using an Enzyme-Linked Immunosorbent Assay (ELISA) kit based on Biotin double antibody sandwich technology. Prior to examination, all frozen samples were allowed to defrost and reach room temperature. The ELISA kits used for this analysis were sourced from Shanghai YI Biont, China.

In addition to salivary sample collection, clinical periodontal parameters, including Bleeding On Probing (BOP), Plaque Index (PLI), clinical

attachment loss (CAL), and probing pocket depth (PPD) were assessed. The laboratory analysis for the measurement of total antioxidant capacity was conducted at the Laboratory of AL-SHAMEEM scientific office.

2.1. Statistical Analysis

T-tests were used to compare parameters between the study and control groups, including total antioxidant capacity, plaque index, probing pocket depth, and clinical attachment loss. A significance level of $p < 0.05$ was applied, and appropriate statistical software was utilized to ensure the accuracy and reliability of the results.

3. Results

The plaque index (PLI) data for the Control group and the Study group are presented in Table 1. The Control group exhibited a mean PLI of 1.142 (SD = 0.524), while the Study group had a slightly higher mean PLI of 1.414 (SD = 0.484). These results indicate a small elevation in the plaque index for the Study group compared to the Control group. Statistical analysis using a t-test yielded a T-value of 2.528, indicating a moderate difference between the groups. The associated P value of 0.013 suggests that this difference in plaque index is statistically significant. The normality of the variables, including PLI, was assessed using the Shapiro-Wilk test, and all variables demonstrated a P value greater than 0.05, indicating a normal distribution.

Table 2 displays the Gingival Bleeding Score for the Control and Study groups. The Control group had a mean score of 5.80 (SD = 3.124), whereas the Study group had a slightly higher mean of 6.36 (SD = 3.903).

Table 1. Plaque Index (PLI) among the study and control groups

Groups	Mean	±SD	±SE	T	P value
Control	1.142	0.524	0.082	2.528	0.013*
Study	1.414	0.484	0.071		

However, the difference in scores between the groups

Table 2. Gingival Bleeding Score among the study and control groups

Groups	Mean	±SD	±SE	T	P value
Control	5.80	3.124	0.488	0.731	0.466
Study	6.36	3.903	0.569		NS

was not statistically significant ($P > 0.05$). These results indicate that there is no substantial difference in the Gingival Bleeding Score between the Control and Study groups. Therefore, it suggests that the factors under investigation may not have a significant impact on gingival bleeding.

Table 3 presents the data comparing Probing Pocket Depth (PPD) between the Control and Study groups. The Control group had lower mean PPD values for PPDs1 (1.098) and PPDs2 (0.341) compared to the Study group with higher mean values of 1.766 and 0.809, respectively. Similarly, for the overall PPD variable, the Control group had a mean PPD of 2.823, while the Study group had a higher mean of 4.401. Statistical analysis using T-tests revealed that these differences in PPD were statistically significant, as indicated by the reported P values (PPDs1: 0.006, PPDs2: 0.012, PPD: 0.000221). These findings suggest that the Study group had more significant pocket depths compared to the Control group.

Table 3. Probing Pocket Depth (PPD) among the study and control groups

Variables	Groups	Mean	±SD	±SE	T	P value
PPDs1	Control	1.098	1.114	0.174	2.791	0.006
	Study	1.766	1.127	0.164		
PPDs2	Control	0.341	0.728	0.114	2.574	0.012
	Study	0.809	0.970	0.141		
PPD	Control	2.823	2.328	0.364	3.744	0.000221
	Study	4.401	1.463	0.213		

In Table 4, a comparison of Clinical Attachment Loss (CAL) data between the Control and Study groups is presented. The Control group had lower mean CAL values for CALs1 (0.341), CALs2 (0.439), and CALmean (1.591) compared to the Study group, which had higher mean values of 1.000, 0.936, and 2.671, respectively. Statistical analysis using T-tests showed that the differences in CAL were statistically significant for CALs1 (P = 0.000179), CALs2 (P = 0.011), and CALmean (P = 0.004). However, CALs3 did not show a significant difference between the groups (P = 0.116). These findings suggest that the study group had increased Clinical Attachment Loss compared to the control group, indicating a potential association between the studied variables and CAL.

value of 3.806, with a standard deviation of 3.333, while the Study group had a lower mean value of 2.534, with a smaller standard deviation of 0.920. The difference in Salivary Total Antioxidant Capacity between the two groups was statistically significant (P = 0.022), suggesting a potential association between the variables under study and antioxidant capacity.

caused by reactive oxygen species. Previous studies have investigated the effects of antioxidants, in

Table 5. Salivary Total Antioxidant Capacity among the study and control groups

Groups	Mean	±SD	±SE	T	P value
Control	3.806	3.333	0.520	2.367	0.022
Study	2.534	0.920	0.134		

Table 4. Clinical Attachment Loss (CAL) among the study and control groups

Variables	Groups	Mean	±SD	±SE	T	P value
CALs1	Control	0.341	0.656	0.102	3.917	0.000179
	Study	1.000	0.885	0.129		
CALs2	Control	0.439	0.673	0.105	2.606	0.011
	Study	0.936	1.092	0.159		
CALs3	Control	0.341	0.617	0.096	1.589	0.116
	Study	0.596	0.876	0.128		
CAL_{mean}	Control	1.591	1.919	0.300	2.936	0.004
	Study	2.671	1.461	0.213		

4. Discussion

Radiation exposure can lead to tissue and molecular damage, highlighting the importance of antioxidants in protecting cells and tissues against the harmful effects of reactive oxygen species. In our study, we evaluated the total antioxidant capacity as a measure of the body's ability to counteract radiation-induced free radicals. Our findings demonstrated a significant decrease in total antioxidant capacity among the study group (2.534) compared to the control group (3.806), supporting the notion that radiation exposure can disrupt the oxidant-antioxidant balance (p = 0.022) [19, 20].

Maintaining adequate levels of antioxidants is crucial for protecting periodontal tissues from oxidative damage

In Table 5, the Salivary Total Antioxidant Capacity data is presented. The control group had a higher mean

conjunction with scaling and root planning, on periodontal tissue destruction [5, 21]. Consistent with these studies, our research revealed a higher prevalence of periodontal disease in the study group compared to the control group, as evidenced by significant differences in plaque index and clinical attachment loss [22, 23].

The diminished antioxidant defense observed in our study may be attributed to prolonged exposure to low-dose irradiation over an extended period. This imbalance in oxidant and antioxidant status aligns with previous research [24]. However, it is important to consider that the number of years worked in the field of radiology may influence the results due to variations in exposure time and dose [1]. In our study, all subjects had a minimum of 5 years of work experience in radiology, which represents a potential limitation [25].

Our study underscores the importance of total antioxidant capacity in the context of periodontal

diseases among ionizing radiation workers. The reduced antioxidant defense observed in the study group, accompanied by significant differences in periodontal parameters, supports the hypothesis that radiation-induced oxidative stress contributes to periodontal tissue damage. It is worth mentioning that the role of antioxidants is neutralizing reactive oxygen species, reducing oxidative stress, and modulating inflammatory processes, which collectively contribute to maintaining periodontal health. Future research should further explore the mechanisms involved and consider the potential influence of different exposure durations and levels in the field of radiology.

5. Conclusion

In conclusion, our study found that ionizing radiation exposure among radiographic workers is associated with decreased total antioxidant capacity, which may contribute to increased periodontal tissue damage and a higher prevalence of periodontal diseases. Maintaining adequate antioxidant levels is crucial for protecting against oxidative damage. Further research is needed to explore underlying mechanisms and consider variations in exposure levels and duration. These findings have implications for preventive measures and interventions to promote periodontal well-being and mitigate the risks associated with occupational radiation exposure in the radiology field.

Acknowledgments

The authors would like to extend their gratitude to the study participants for their valuable contribution and cooperation throughout the research process. The authors also acknowledge Dr. A. Taha for his invaluable assistance in data analysis and statistical work.

The research conducted in this study has received ethical approval from the ministries of the environment, health, higher education, and scientific research.

References

1- Siegal Sadetzki *et al.*, "Long-Term effects of exposure to ionizing irradiation on periodontal health status–the tinea capitis cohort study." *Frontiers in Public Health*, Vol. 3p. 226, (2015).

2- Hiroko P Indo *et al.*, "A mitochondrial superoxide theory for oxidative stress diseases and aging." *Journal of clinical biochemistry and nutrition*, Vol. 56 (No. 1), pp. 1-7, (2015).

3- Omayma AR Abozaid, Fatma SM Moawed, Mostafa A Farrag, and Abdel Aziz A Abdel Aziz, "4-(4-Hydroxy-3-methoxyphenyl)-2-butanone modulates redox signal in gamma-irradiation-induced nephrotoxicity in rats." *Free Radical Research*, Vol. 51 (No. 11-12), pp. 943-53, (2017).

4- Jianhui Chang *et al.*, "28Si total body irradiation injures bone marrow hematopoietic stem cells via induction of cellular apoptosis." *Life sciences in space research*, Vol. 13pp. 39-44, (2017).

5- Ahmet Cemil Talmaç and Metin Çalişir, "Antioxidants and Periodontal Diseases." in *Gingival Disease-A Professional Approach for Treatment and Prevention*: *IntechOpen*, (2019).

6- Mangaluru Deralakatte, "Salivary antioxidant status following radiotherapy in patients with head and neck cancer." *Int J Anat Res*, Vol. 7 (No. 3.2), pp. 6793-99, (2019).

7- Shahba' Munther, "The effects of cigarette smoking and exercise on total salivary antioxidant activity." *The Saudi Dental Journal*, Vol. 31 (No. 1), pp. 31-38, (2018).

8- Karoline Koch, Susannah Havermann, Christian Büchter, and Wim Wätjen, "Caenorhabditis elegans as model system in pharmacology and toxicology: effects of flavonoids on redox-sensitive signalling pathways and ageing." *The Scientific World Journal*, Vol. 2014(2014).

9- Alexandre Vallée, Yves Lecarpentier, Rémy Guillevin, and Jean-Noël Vallée, "Interactions between TGF-β1, canonical WNT/β-catenin pathway and PPAR γ in radiation-induced fibrosis." *Oncotarget*, Vol. 8 (No. 52), p. 90579, (2017).

10- Ulku Baser, Hikmet Gamsiz-Isik, Emine Cifcibasi, Evin Ademoglu, and Funda Yalcin, "Plasma and salivary total antioxidant capacity in healthy controls compared with aggressive and chronic periodontitis patients." *Saudi medical journal*, Vol. 36 (No. 7), p. 856, (2015).

11- Lue Sun *et al.*, "Total body irradiation causes a chronic decrease in antioxidant levels." *Scientific reports*, Vol. 11 (No. 1), p. 6716, (2021).

12- VMLB Deo and ML Bhongade, "Pathogenesis of periodontitis: role of cytokines in host response." *Dentistry today*, Vol. 29 (No. 9), pp. 60-2, 64, (2010).

13- Jalal Ordoni, Vida Sargazi, Zeinab Yazdi Stoodeh, Yazdan Salimi, and Dariush Askari, "Total Antioxidant Capacity level in Radiation Workers and other Staffs of Hospital in Sistan and Baluchestan Province." *Iranian Journal of Medical Physics*, Vol. 15 (No. Special Issue-12th. Iranian Congress of Medical Physics), pp. 164-64, (2018).

14- Andrea Ghiselli, Mauro Serafini, Fausta Natella, and Cristina Scaccini, "Total antioxidant capacity as a tool to assess redox status: critical view and experimental data." *Free Radical Biology and Medicine*, Vol. 29 (No. 11), pp. 1106-14, (2000).

15- Baidaa T Ali and Maha Sh Mahmood, "Assessment of Salivary Total Antioxidants Capacity Levels of Patients with Chronic Periodontitis in Comparison to Healthy Control." *Journal of Baghdad College of Dentistry,* Vol. 30 (No. 1), pp. 58-62, (2018).

16- WK Leung, LJ Jin, LP Samaranayake, and GKC Chlu, "Subgingival microbiota of shallow periodontal pockets in individuals after head and neck irradiation." *Oral microbiology and immunology,* Vol. 13 (No. 1), pp. 1-10, (1998).

17- Zehra ARDIÇ, Tahir Kemal Şahin, UYAR Mehmet, Hasan Küçükkendirci, İbrahim KILINC, and Elif Nur YILDIRIM ÖZTÜRK, "Effects of occupational exposure to ionizing radiation on oxidative stress and inflammatory markers in healthcare workers of a university hospital in Konya, Turkey." *Journal of Cellular Neuroscience and Oxidative Stress,* Vol. 13 (No. 2), pp. 994-1003, (2021).

18- Jérôme Lacombe *et al.*, "Quantitative proteomic analysis reveals AK2 as potential biomarker for late normal tissue radiotoxicity." *Radiation Oncology,* Vol. 14 (No. 1), pp. 1-11, (2019).

19- Salih Omer Haji and Jian Lateif Hussein, "Biochemical Study on the Impact of Radiation-induced Oxidative Stress on Radiographers in the X-ray and CT-scan Departments." *Baghdad Science Journal,* Vol. 20 (No. 3), pp. 0676-76, (2023).

20- Ali Akbar Malekirad *et al.*, "Oxidative stress in radiology staff." *Environmental toxicology and pharmacology,* Vol. 20 (No. 1), pp. 215-18, (2005).

21- Hubert Thierens, Anne Vral, and Leo De Ridder, "A cytogenetic study of radiological workers: effect of age, smoking and radiation burden on the micronucleus frequency." *Mutation Research/Environmental Mutagenesis and Related Subjects,* Vol. 360 (No. 2), pp. 75-82, (1996).

22- Ghadah N Alhusaini and Ahlam T Mohammed, "Periodontal status and salivary flow rate among diagnostic radiology department workers." *Journal of Baghdad College of Dentistry,* Vol. 31 (No. 2), pp. 32-35, (2019).

23- Philippe Bouchard, Pierre Boutouyrie, Catherine Mattout, and Denis Bourgeois, "Risk assessment for severe clinical attachment loss in an adult population." *Journal of periodontology,* Vol. 77 (No. 3), pp. 479-89, (2006).

24- Dayanidhi Kumar *et al.*, "Genetic instability in lymphocytes is associated with blood plasma antioxidant levels in health care workers occupationally exposed to ionizing radiation." *International journal of toxicology,* Vol. 35 (No. 3), pp. 327-35, (2016).

25- Jianfang Gao, Xiaomei Dong, Taixiu Liu, Lilong Zhang, and Lin Ao, "Antioxidant status and cytogenetic damage in hospital workers occupationally exposed to low dose ionizing radiation." *Mutation Research/Genetic Toxicology and Environmental Mutagenesis,* Vol. 850p. 503152, (2020).