Middle Black Sea Journal of Health Science / Mid Blac Sea J Health Sci
February 2022; 8(1):1-8

RESEARCH ARTICLE
DOI: 10.19127/mbsjohs.979585

Evaluation of Gross Alpha and Beta Radioactivity Concentrations in Tooth Samples

Zerrin Unal Erzurumlu[1](ID), Arzu Sahin[2](ID), Cigdem Guler[3](ID) ,
Mehmet Melih Omezli[4](ID), Mehmet Emin Korkmaz[5](ID), Osman Agar[6](ID), Soner Cankaya[7](ID)

[1]Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Ordu University, Ordu, Turkey
[2]Department of Basic Medical Sciences Department of Physiology, Faculty of Medicine, Usak University, Usak, Turkey
[3]Department of Pediatric Dentistry, Faculty of Dentistry, Ordu University, Ordu, Turkey
[4]Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Ordu University, Ordu, Turkey
[5]Department of Physics, Kamil Özdag Faculty of Science, Karamanoglu Mehmetbey University, Karaman, Turkey
[6]Department of Medical Imaging Techniques, Karamanoglu Mehmetbey University, Karaman, Turkey
[7]Department of Sport Management. Yasar Dogu Faculty of Sport Sciences, Ondokuzmayis University, Samsun, Turkey

Received: 06 August 2021, Accepted: 03 November 2021, Published online: 25 February 2022

Abstract
Objective: Teeth are used as an important data source to estimate radioactivity accumulation in individuals. This study aimed to evaluation the gross alpha (GA) and gross beta (GB) radioactivity concentrations in tooth samples.

Methods: Mandibular permanent first molar teeth of individuals living in the Middle Black Sea region were used for the study to ensure standardization. The teeth samples were divided into 4 groups according to the age factor (Group 1: 6-15 years, Group 2: 16-30 years, Group 3: 31-45 years, and Group 4: 46-65 years). Each group was divided into two subgroups according to gender factor. Measurements were completed with a nuclear spectroscopic system containing a gas-flow proportional counter. Data were analyzed statistically.

Results: While a statistically significant difference was detected among groups for GA radioactivity concentration ($p<0.05$), no significant difference was detected among groups for GB ($p>0.05$). Mean GA value was higher in Group 1 (6-15 years) compared to the other groups. There was no statistically significant difference between the genders in both GA and GB radioactivity concentrations for all groups ($p>0.05$).

Conclusion: While the GA radioactivity concentration was affected by the age factor, it was not affected by the gender factor.

Keywords: Teeth, gross alpha, gross beta, radioactivity, radiation

Suggested Citation: Unal Erzurumlu Z, Sahin A, Guler C, Omezli M M, Korkmaz M E, Agar O, Cankaya S. Evaluation of Gross Alpha and Beta Radioactivity Concentrations in Tooth Samples. Mid Blac Sea Journal of Health Sci, 2022;8(1):1-8

Address for correspondence/reprints:
Zerrin Unal Erzurumlu
Telephone number: +90 452 212 12 83
E-mail: zuerzurumlu@gmail.com

INTRODUCTION

Radiation is a natural part of our environment and is defined as "energy traveling through the environment". Radiation is investigated under two main headings of ionizing radiation and non-ionizing radiation according to the amount of energy transported. Radiation with real importance in terms of human health and the environment is ionizing radiation (1,2).

The human body is exposed to natural and artificial sources of ionizing radiation. Natural radiation sources comprise the largest portion of radiation exposure every year and may be classified in two broad categories as cosmic and terrestrial contributions. High-energy cosmic rays and secondary radiation formed in the atmosphere comprise the cosmic contribution. Radioactive nuclides produced during the earth's formation and still found in the crust comprise the terrestrial contribution. Exposure to Radon (^{222}Rn) forms the most significant contribution to total dose (1,3,4). Artificial sources are due to human activities involving industrial and nuclear technology including medical applications, nuclear reactors, atmospheric nuclear tests and accidents, and traditional mining operations. Though it may vary in different regions in the world, it is considered that an individual is exposed to about 2.4 mSv of natural radiation each year. The maximum dose permitted professionally is 20 mSv annually. Annual exposure to artificial radiation sources comprises a relatively lower amount of the dose. Just as the human body is exposed to external radiation due to pollution of air, soil, water, and plants by radioactive elements, it may be exposed to internal radiation with transport of radioactive material into the human body and accumulation in certain regions of the body (5,6).

Radioactivity is the process of spontaneous fission or decay of unstable atoms or elements to gain more balanced nuclear structure. Unstable elements have natural radioactivity. Stable elements are made radioactive as a result of core bombardment in nuclear reactors to create artificial radioactive elements which produce radiation as a result of radioactive decay (5,7,8).

Alpha particles comprise two neutrons and two protons; as a result, the electrical load is positive. Alpha radiation comes from naturally formed elements like uranium and radium and from some human-made elements. Due to their load and heavy mass, alpha particles densely ionize matter and rapidly lose their energy. They cannot pass the first layer of the skin; however, if a material releasing alpha particles is eaten as food or taken in through the airway, they may affect body cells (9). Beta particles are rapidly moving electrons or positrons emitted from an atom. They may travel several cm through skin or water. They can be stopped by thin aluminum or plastic sheets. GA and GB activity concentrations are defined as total radioactivity from all alpha and beta emitters (10,11). GA and GB' measurements have the quality of indicators, with radioactivity of radioactive material releasing alpha or beta rays determined in Becquerels (Bq) (10,11).

Due to their slow metabolism and retraction, teeth have recently been used for biological modeling. The presence of trace elements in dental structures covers a wide range of fields from archeology to environmental studies, and biomedicine. Teeth provide important scientific data about some substances found in the individual's body. Recently, it has become popular to use human teeth for both radioactivity measurements and fundamental analysis studies (5,10).

Teeth have been used as an important data source in determining the accumulation of radioactivity of individuals (4,12-14). Teeth have been investigated for GA and GB radioactivity concentrations in different region from Turkey (4,5,15-17). However, the work done in the Black Sea Region is limited (15,17). The aim of this study is to determine the GA and GB concentrations in permanent tooth samples belonging to individuals living in the Central Black Sea region. The null hypotheses tested were that (1) the age factor does not affect GA and GB radioactivity concentrations values, and (2) gender factor does not affect GA and GB radioactivity concentrations values.

METHODS

The Clinical Research Ethics Committee of Ordu University approved this study (2017/100). This study follows the Helsinki Declaration. In addition, informed consent was obtained from patients, giving permission to use the teeth for the study purposes after removal.

For creation of study groups and determination of sample size in the groups, Mangano et all's (18) study was used as a guide. Accordingly, with alpha=0.05 and Power=0.80, the minimum sample number required per group is 23. The sex distribution in each group was assigned so as not to create a statistical difference.

A total of 97 mandibular permanent first molar teeth were used for the study. The teeth samples were obtained from individuals between the ages of 6-65 and living in the Middle Black Sea province, who were decided to have a tooth extraction for any reason at Ordu University Faculty of Dentistry. In addition, teeth samples with any restoration, teeth samples of individuals who smoked, had previous exposure to any imaging method involving radiation for the head-neck region, or and radiotherapy were not included in the study.

Preparation of samples and groups

The teeth samples were divided into 4 groups according to the ages of the individuals as Group 1: aged with 6-15 years (n=25), Group 2: aged with 16-30 years (n=25), Group 3: aged with 31- 45 years (n=23), Group 4: aged with 46-65 years (n=24). Additionally, they were investigated according to the gender of the individual.

Each sample was stored in physiological saline (Osel/ İstanbul/ Turkey). They were mechanically cleaned with a hard brush and weights were recorded. They were dried in an oven for 120 min (Mipro – MLF, Turkey). Then pressed and ground for 60 seconds. The powdered samples were transferred to stainless steel planchettes. All samples had GA and GB activity concentrations counted with a nuclear spectroscopic system containing gas-flow proportional counters (MPC-9604-ASC-950-DP, USA) (4,19-22). The system was calibrated for alpha and beta energies. Standard samples with equal concentrations were preperated. To calibrate the alpha and beta energies in the system 241Am (3.78 kBq) and 90Sr (3.76 kBq) were used. Count efficiency for the system was 38-40 % for alpha and 95-99 % for beta radiation. Each sample was counted three times. The results are given as arithmetic mean with standard error (4,19).

Statistical analysis

GA and GB radioactivity concentration values obtained in the research with the aim of revealing differences according to research groups and individual gender, firstly had the normality assumption checked with the Shapiro-Wilk test ($p<0.05$). Based on the results of the normality test, differences among the age groups in terms of measurement values were determined with the Kruskal-Wallis and Dunn's multiple comparison tests. Differences according to gender were determined with the Mann-Whitney U test. The correlation between ages of individuals with GA and GB values was determined with the Spearman's rho correlation coefficient. Research findings are given as n, mean, standard deviation, median and IQR values. All statistical calculations were performed in the SPSS V. 22.0 statistical program. Research findings had significance level of $p<0.05$ accepted as significant.

RESULTS

The distribution of GA and GB concentrations is presented in Table 1. Statistically significant difference was detected among groups for GA radioactivity concentration ($P<0.05$). Mean GA value was higher in Group 1 (6-15 years) compared to the other groups ($P<0.05$). However, there was no statistically significant difference between the groups for GB radioactivity concentration ($P>0.05$). There was no significant correlation identified between age and GA and GB radioactivity concentrations (r =-0.173, P=0.090 and r=0.022, P= 0.828, respectively).

The mean GA and GB radioactivity concentrations values were 0.167±0.102 Bq/g and 0.459±0.805 Bq/g, respectively. The minimum and maximum GA radioactivity concentrations values were 0.056 and 0.610 Bq/g. The minimum and maximum GB radioactivity concentrations values were 0.043 Bq/g and 2.799 Bq/g.

The mean GA and GB radioactivity concentrations for male and female individuals in the study according to age groups are given in Table 2. There were no significant differences between the genders for both GA and GB radioactivity values in groups ($P>0.05$). When all tooth samples are assessed according to the gender of individuals, the mean GA and GB values in female were 0.159±0.100 Bq/g and 0.552±0.889 Bq/g, the mean GA and GB values in male were 0.177±0.105 Bq/g and 0.346±0.683 Bq/g, respectively.

Table 1. Distibution of GA and GB radioactivity concentrations

Groups		n	Mean	Std. Deviation	Median	IQR	P*
Gross Alpha	Group 1	25	0.249^{a}	0.157	0.149	0.271	**0.002**
	Group 2	25	0.129^{b}	0.053	0.119	0.058	
	Group 3	23	0.129^{b}	0.027	0.140	0.041	
	Group 4	24	0.159^{ab}	0.061	0.144	0.069	
Gross Beta	Group 1	25	0.531	0.897	0,099	0,061	0.657
	Group 2	25	0.308	0.688	0.093	0.021	
	Group 3	23	0.460	0.713	0.096	0.056	
	Group 4	24	0.539	0.920	0.097	0.087	

Different superscripts **a** and **b** show statistically significant difference among groups ($P<0.05$)
P*=Kruskal-Wallis Test

Table 2. GA and GB radioactivity concentrations for genders according to groups

	Gender	n	Mean	Std. Deviation	Median	IQR	P*
Group 1							
Gross Alpha	Male	13	0.270	0.145	0.205	0.270	0.183
	Female	12	0.226	0.173	0.144	0.226	
Gross Beta	Male	13	0.280	0.658	0.094	0.033	0.341
	Female	12	0.803	1.061	0.101	2.102	
Group 2							
Gross Alpha	Male	8	0.110	0.034	0.108	0.062	0.336
	Female	17	0.138	0.058	0.120	0.088	
Gross Beta	Male	8	0.154	0.197	0.091	0.058	0.749
	Female	17	0.380	0.822	0.093	0.015	
Group 3							
Gross Alpha	Male	8	0.146	0.019	0.144	0.006	0.098
	Female	15	0.119	0.027	0.130	0.052	
Gross Beta	Male	8	0.531	0.800	0.097	1.243	0.651
	Female	15	0.421	0.689	0.096	0.022	
Group 4							
Gross Alpha	Male	15	0.148	0.055	0.141	0.035	0.310
	Female	9	0.176	0.069	0.149	0.112	
Gross Beta	Male	15	0.406	0.822	0.096	0.034	0.493
	Female	9	0.762	1.079	0.116	1.694	

P*= Mann-Whitney U test

DISCUSSION

The human body is exposed to external radiation due to pollution of air, soil, water, and plants by radioactive elements. Humans may be exposed to internal radiation due to intake of radioactive material through different routes including the respiration system, digestive system, or dermal absorption. These elements accumulate in different sections of the organism linked to the chemical properties (5). As a result, it is very important to analyze individuals for some radioactive material with properties of accumulating in the body. Total exposure to natural or artificial ionizing radiation sources may be determined by investigating teeth. There are previous studies examining GA and GB values in drinking water and teeth (1,4,5,17,23). Therefore, in present study, GA and GB values were examined in dental samples.

In the current study, the effect of age and gender factors on GA and GB values was evaluated in permanent first molar tooth samples. Considering our results, while a statistically significant difference was detected among groups for GA radioactivity concentration, no significant difference was detected among groups for GB. Therefore, the first null hypothesis was partially rejected. In addition, no statistically significant difference was found between the genders in both GA and GB radioactivity concentrations for all groups. Therefore, the second null hypothesis was accepted.

We are exposed to many adverse effects due to exposure to artificial radiation for a variety of reasons during our lives and because of natural radiation affecting our bodies in nature. Radioactivity measurements are important to assess the effect of radiation on the environment and living organisms. This type of analysis may assist in preventing some health problems that may be experienced by of variations occurring from the first stage of life until the end in humans. As radionuclides (226Ra, 228Ra, 210Po, 40K) are similar to Ca in terms of structure and precipitation properties, in the body accumulation occurs especially in bones and teeth (5,24,25).

There are limited numbers of studies about GA and GB activity measurement in teeth in the literature. Penna-Franca (26) reported the radionuclide concentration in teeth from HLNRA inhabitants in Brazil was 0.76±0.30 Bq/kg (ash). Yamamoto et al (13) measured 226Ra activity in permanent teeth and bones of those living in different places in Japan. They reported that there was no appreciable difference in concentration of 226Ra between various permanent tooth samples in different age groups in Tokyo (13). Sogut et al. (4) measured GA and GB activity concentrations in human tooth and stated GA and GB have different values for different age groups. The findings of our study are partially compatible with the findings of Sogut et al. (4). In our study, a significant difference was found between age groups for GA radioactivity concentration, and no significant difference was found between age groups for GB value. Different results may have been due to the regional and nutritional differences or the differences in the type of tooth used and the sample size. In addition, permanent first molar teeth may carry traces related to exposure doses during both intrauterine life and after birth. The use of natural and artificial foods such as breast milk and formula may also have caused the difference in results.

There are studies examining the mean GA and GB values in teeth in Turkey (4,5,17). Sogut et al. (4) reported the GA and GB values were 0.203-0.534 Bq/g and 0.010-0.453 Bq/g for females, 0.009–1.168Bq/g and 0.071–0.204 Bq/g for males, respectively in a study from Adıyaman in Turkey. Taskin et al. (5) reported the mean GA and GB values were 31.0-47.8 Bq/kg and 71.2-89.2 Bq/kg for females, 52.7-82.1 Bq/kg and 114.0-154.4 Bq/kg for males, respectively in a study from Istanbul, Turkey. Ugur et al. (17) compared GA and GB radioactivity in the Black Sea region and Cukurova region in their study and reported values were higher in the Black Sea region. In our study, the mean GA and GB values for teeth samples from females were 0.159±0.100 Bq/g and 0.552±0.889 Bq/g, males were 0.177±0.105 Bq/g and 0.346±0.683 Bq/g, respectively. Different results in the literature may be due to environmental conditions, eating habits and use of different sample sizes.

This study is considered to have some limitations. First, lack of personal information like occupation and diet of patients. Second, only permanent first molar teeth were examined. Different results can be obtained when different type of the teeth was included in the study. Third, tooth samples belonging to the individuals over 65 years of age were excluded from the study because the target n number in the group could not be reached. Finally, the sample size was limited due to the long duration of the analysis and the high cost. Data obtained in our study analyzing radioactivity in permanent first molar teeth from the Central Black Sea region provide valuable contributions to the literature. However, additional studies should be conducted to evaluate the effects of different parameters on GA and GB.

CONCLUSION

- Statistically significant difference was detected among groups for GA radioactivity concentration ($p<0.05$).
- Mean GA value was higher in Group 1 (6-15 years) compared to the other groups.

• No statistically significant difference between the genders in both GA and GB radioactivity concentrations for all groups (p>0.05).

Ethics Committee Approval: Ethics committee approval was received for this study from Ordu University Clinical Research Ethics Committee (2017/100)

Peer-review: Externally peer-reviewed.

Author Contributions: Concept: Z.U.E., A.S., C.G.; Design: Z.U.E., A.S., C.G.; Literature search: Z.U.E., A.S., C.G. M.M.O.; Data Collection and Processing: Z.U.E., A.S., C.G. M.M.O.; Analysis or Interpretation: Z.U. E., A.S., C.G., M.M.O., M.E.K., O.A., S.C.; Writing: Z.U. E., A.S., C.G., M.M.O., M.E.K., O.A., S.C.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: This work was supported by the Ordu University, Scientific Research Projects Coordination Unit, Ordu; Turkey (Grant number: AP-1704).

REFERENCES

1. Aghamiri SMR, Ghorbani Z, Darafsheh A, Torabzadeh H, Fathivand AA, Minuchehr A, et al. 226Ra concentration in the teeth of habitants of areas with high level of natural radioactivity in Ramsar. J Environ Radioact. 2006;89(3):212-218.
2. White SC, Pharoah MJ. Oral Radiology principals and ınterpretation. 7 th ed. Mosby, Canada, 2014. p. 1-28.
3. Cinelli G, Tollefsen T, Bossew P, Gruber V, Bogucarskis K, De Felice L, et al. Digital version of the European Atlas of natural radiation. J Environ Radioact. 2019;196:240-252.
4. Sogut O, Aydin MF, Kucukonder E, Zorer OS, Dogru M. Measurement of gross alpha and gross beta activity concentrations in human tooth. J Environ Radioact. 2010;101(3):226-229.
5. Taskin H, Kobya Y, Tokgoz M, Bassari A, Yesilkanat CM. Biomonitoring of trace elements and gross alpha/ beta radioactivity levels in human teeth: A case study from Istanbul, Turkey. Microchemical Journal. 2018;141:458-465.
6. Clemente GF, Renzetti A, Santori G, Steinhäusler F, Pohl-Ruling J. Relationship between the 210Pb content of teeth and exposure to Rn and Rn daughters. Health Phys. 1984;47(2):253-262.
7. Delibacak S, Ongun AR. Influence of treated sewage sludge applications on corn and second crop wheat yield and some soil properties of sandy loam soil. Fresen Environ Bull. 2016;25(1):43-54.
8. Kir I, Erdogan M, Engin MS, Cay S. Trace metals in sediment, water and their bioaccumalation in Carp (Cyprinus Carpio L., 1758) samples, captured from the Karacaoren (I) Dam Lake, Turkey. Fresen Environ Bull. 2016;25(9):3557-3562.
9. Beir VI. Report of the Committee on the Biological effects of Ionizing Radiation, National. Research, Council. 1999.
10. Brown CJ, Chenery SR, Smith B, Mason C, Tomkins A, Roberts GJ, et al. Environmental influences on the trace element content of teeth—implications for disease and nutritional status. Arch Oral Biol. 2004;49(9):705-717.
11. Corbacho JA, Zapata-García D, Montaña M, Fons J, Camacho A, Guillén J, et al. Selection of the appropriate radionuclide source for the efficiency calibration in methods of determining gross alpha activity in water. J Environ Radioact 2016;151:22-7.
12. Butler FE. Strontium-90 in human teeth. Natur. 1961;11(189):848-849.
13. Yamamoto M, Hinoide M, Ohkubo Y, Ueno K. Concentration of 226Ra in human teeth. Health Phys. 1994;67(5):535-540.

14. Kulev YD, Polikarpov GG, Prigodey EV, Assimakopoulos PA. Strontium-90 concentrations in human teeth in South Ukraine, 5 years after the Chernobyl accident. Sci Total Environ. 1994;155(3):215-219.

15. Baltas H, Sirin M, Senel F, Devran F. Determination of natural radionuclides and some metal concentrations in human tooth samples in the Rize province, Turkey Int J Environ Health Res. 2019; 31(1):20-33.

16. Kavun Y, Boztosun I, Đapo H, Maras I, Segebade C. Determination of the Sr/Ca ratio of tooth samples by photoactivation analysis in Southern Turkey. Radiochimica Acta. 2018;106(9):759-768.

17. Ugur A, Sahan H, Sahan M, Yegingil Z, Gorur S. Investigation of the relation between environmental radioactivity and radioactivity in human teeth who lives in this environment. Fizika (Baku). 2010;16:537-540.

18. Mangano JJ, Gould JM, Sternglass EJ, Shermand JD, McDonnelle W. An unexpected rise in strontium-90 in US deciduous teeth in the 1990s. Sci Total Environ. 2003;317 (1-3):37-51.

19. Dogru M, Kulahci F. Iso-radioactivity curves of the water of the Hazar Lake, Elazig, Turkey. J Radioanal Nucl Chem. 2004;260(3):557-562.

20. Zorer OS, Ceylan H, Dogru M. Assessment of some trace heavy metals and radioactivity concentration in water of Bendimahi River Basin (Van, Turkey). Environ Monit Assess. 2008;147(1-3),183-90.

21. Zorer OS, Ceylan H, Dogru M. Determination of heavy metals and comparison to gross radioactivity concentration in soil and sediment samples of the Bendimahi River Basin (Van, Turkey). Water, air, and Soil Pollution. 2009;196:75-87.

22. Zorer OS, Ceylan H, Dogru M. Gross alpha and beta radioactivity concentration in water, soil and sediment of the Bendimahi River and Van Lake (Turkey). Environ Monit Assess. 2009;148(1-4):39-46.

23. Rothe WE. Gross alpha radioactivity of human bones and teeth. Radiol Health Data Rep. 1966;7(3):204-205.

24. Dewit T, Clulow V, Jackson JS, Mitchel REJ. Uranium and uranium decay series radionuclide dynamics in bone of rats following chronic uranium ore dust inhalation. Health Phys. 2001;81(5):502-513.

25. Wrenn ME, Durbin PW, Howard B, Lipsztein J, Rundo J, Still ET, et al. Metabolism of ingested U and Ra. Health Phys. 1985;48(5):601-633.

26. Penna-Franca E. Review of Brazilian investigations in areas of high natural radioactivity part II: internal exposure and cytogenetic survey. In: Proceedings of the International Symposium on Areas of High Natural Radioactivity, Pocosde caldas, Brazil, 1977; 29–48.