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The Impact of Radiation Dose Variation in Panoramic Dental Examination on Salivary Amylase Enzyme Activity

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ABSTRACT

The surge in oral and dental diseases has amplified the significance of dental panoramic imaging as a diagnostic tool for healthcare professionals. However, such imaging subjects patients to radiation, impacting salivary pH and amylase enzyme activity. This study of 30 patients aimed to measure radiation doses and their effects on salivary pH and amylase enzyme activity. Radiation doses were quantified using a Thermoluminescent Dosimeter (TLD-100) and analyzed with a TLD reader. Salivary pH was determined using a digital pH meter, and amylase enzyme activity was assessed through the iodine method, involving a reaction between a 1% amylum solution, iodine solution, and saliva. Results showed an average radiation dose of 2.33 μSv, significantly affecting salivary pH. Specifically, 28 patients experienced an average pH decrease of 0.34, while 2 had an average pH increase of 0.385. These pH changes corresponded with variations in amylase enzyme activity. In 17 patients, amylase activity increased by an average of 0.75×10^{-4} units/mL, while 13 patients exhibited an average decrease of 0.96×10^{-4} units/mL. This underscores the intricate relationship between radiation dose, salivary pH, and amylase enzyme activity, warranting further exploration within dental panoramic imaging.

1. INTRODUCTION

Radiation has many benefits in life. One of them is used in the health sector, which is in the field of radiodiagnostics. Radiodiagnostics is the utilization of ionizing radiation with X-ray machine for diagnostic purposes. Ionizing radiation is radiation that can ionize the material it passes through. The output of the X-ray machine is an image that can help doctors diagnose disease. One rapidly growing disease is oral and dental which can be seen based on World Health Organization (WHO) data. The status of global oral health is concerning and requires urgent action. Over the past 30 years, the global number of cases has increased by 1 billion. Dental caries is one of the oral diseases that, in 2019, case numbers are estimated at 514 million. Severe periodontal disease is estimated to have more than 1 billion cases worldwide. Meanwhile, in 2020, lip and oral cavity cancer ranked 16th among all types of cancer,

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which WHO stated that the South-East Asia region has an oral cancer rate almost double the global average (World Health Organization, 2022). Based on many cases, dental panoramic is one of the radiodiagnostics equipment that can help doctors diagnose oral and dental diseases through the results of the oral image and what treatment should be done to the patient.

Dental panoramic is a tool that produces images of the jaw and teeth, each on a single extraoral radiographic film (Rushton & Rout, 2006). Dental panoramic or panoramic radiography is a two-dimensional (2D) dental X-ray examination that captures the entire oral cavity in a single image, including the teeth, upper and lower jaws, as well as surrounding structures and tissues. The resulting images of the maxillary sinuses, tooth position, and other bone abnormalities. Dental panoramic has an X-ray tube that when given a high voltage, electrons as electrically charged particles will move at high speed, when passing near the nucleus of an atom, the strong electrostatic attraction force of the atomic nucleus can cause the direction of electron motion to bend sharply. This causes the electrons lose their energy by emitting electromagnetic radiation known as Bremsstrahlung X-rays.

Panoramic dental radiography uses a losw-dose ionizing radiation to capture images. Although the radiation dose is low, there may be effects from radiation exposure. Two biological effects of radiation are deterministic effect, which which are damaging effects on the body that occur at a specific high dose or above a threshold dose, and stochastic effects, which are random effects that can occur at any dose, even a very low one (Choudhary, 2018). Thus, when radiation is exposed to the mouth, other parts around the mouth, such as the parotid glands, may also be exposed (Himammi & Hartomo, 2021).

The parotid gland is the largest salivary gland and is located within the oral cavity. It produces saliva, a colourless complex fluid that aids digestion and maintains the hydrogen (pH) power balance of the mouth. The parotid gland is radiation-sensitive, and radiation from panoramic dental radiographs can interact with matter through ionization and is likely to affect the pH of saliva. In saliva, some enzymes start the digestive process and balance the mouth’s pH. Enzymes contained in saliva are amylase enzymes (Rahayu & Kurniawati, 2018).

Amylase, an enzyme found in saliva produced by the parotid gland, converts starch and glycogen into smaller carbohydrate units (Rahayu & Kurniawati, 2018). Saliva functions best when its pH is maintained in an optimal balance. Ionizing radiation can affect salivary pH, either lowering or increasing it. The pH condition of saliva affects the activity of the amylase enzyme, as the enzyme can only work at a certain pH. Therefore, changes in salivary pH will affect amylase enzyme activity (Tatah & Otitoju, 2015).

Previous studies have examined the impact of radiation exposure on salivary pH and amylase enzyme activity. Susanti et al. (2016) analysed saliva samples from eight patient, which showed a significant decrease in salivary pH after radiation exposure. Similarly, Nurgalih et al. (2019) observed a reduction in salivary pH among 30 patients who had undergone radiation exposure, which corroborated the findings of Susanti et al. (2016). Furthermore, Amatulhaq et al. (2022) conducted a prior investigation into the effects of radiation exposure on amylase enzyme activity. Their study involved 20 patients and demonstrated significant alterations in amylase enzyme activity, with both increases and decreases observed as a result of the exposure.

Building upon prior research findings, this study aimed to further investigate the impact of radiation exposure on salivary pH and amylase enzyme activity. The rationale behind this investigation stems from the potential disruption to the oral digestive process that can result from fluctuations in salivary pH and amylase enzyme activity. Such disruptions may inhibit the conversion of food into smaller carbohydrate units, affecting overall digestion. The main objectives of this study include quantifying and analysing the radiation dose delivered to patients through dental panoramic imaging. In addition, this study aims to elucidate the intricate relationship between changes in salivary pH and the subsequent impact on amylase enzyme activity. Furthermore, this study also aims to ascertain the effect of radiation dose on the mobility of amylase enzymes within the oral environment. To achieve these objectives, radiation dose measurements will be performed employing TLD-100. The TLD-100 has superior sensitivity and accuracy, closely resembles body tissue, remains resistant to environmental factors, and has a compact size that facilitates precise placement. The radiation dose given to patients in this study is varied based on their respective Body Mass Index (BMI).

2. METHOD

The X-ray source utilized was derived from a dental panoramic machine (Carestream Dental, USA), situated at Universitas Andalas Hospital. Radiation dose measurements were performed using a TLD-100 dosimeter sourced from Pusat Riset Teknologi Keselamatan, Metrologi, dan Mutu Nuklir, Badan Riset Inovasi Nasional (PRTKMMN BRIN), Jakarta. The processing and subsequent reading of the TLD-100 data were carried out at the Dosimetry Laboratory of PRTKMMN BRIN, utilizing a TLD reader (Harshaw model 3500, USA).

Salivary pH levels were assessed both before and after irradiation, employing a digital pH meter. Simultaneously, the testing of amylase enzyme activity was executed using an iodine test, conducted at the Biochemistry Laboratory of Universitas Andalas in Padang. The study encompassed the collection of saliva samples from a cohort of 30 patients, collected both before and after radiation exposure.

The selection criteria for research subjects entailed adult females who were non-smokers, not menstruating, devoid of oral diseases, and not under medication. To account for exposure-related factors, patients were categorized based on their Body Mass Index (BMI).

It is important to note that this research received ethical approval from the Health Research Ethics Committee of M. Djamil Hospital in Padang, bearing the reference number LB.02.02/5.7/19/2023. The approval is based on considerations of patient safety during data collection, patient data privacy, radiation protection, patient consent, research procedures, and research benefits. Upon gathering and consolidating all pertinent data, comprehensive analyses were conducted using descriptive statistics, with the data being graphically represented to facilitate interpretation.

2.1 Registration of Patients

The research begins by asking for patient consent to become the research object and collecting patient data. Patients were determined based on age, i.e., adult women who were willing to be the research object with the criteria that have been mentioned. Data will be used to classify patients based on BMI. Underweight patients (BMI < 18.5) were given a voltage of 72 kV, a current of 8 mA, and an exposure time of 10.2 s. Normal-weight patients (BMI from 18.5 to 22.9) were given a voltage of 73 kV, a current of 10 mA, and an exposure time of 10.8 s. Overweight patients (BMI from 23 to 24.9) were given a voltage of 76 kV, a current of 10 mA, and an exposure time of 11.5 s.

2.2 Obtaining the Research Data

The collection of research data began by collecting the patient's saliva before radiation exposure using the spitting method, the patient was asked to sit comfortably and look down, and to allow saliva to pool in their mouth without swallowing. About every 60 seconds, the patient spat the saliva into a collection container. This was repeated for about 5 minutes (Rahayu & Kurniawati, 2018). Patients were asked not to eat or drink for one hour before radiation exposure.

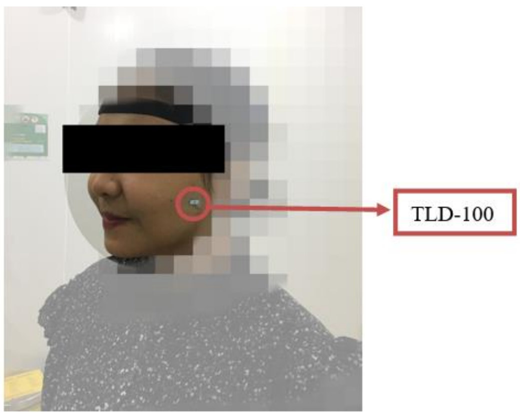

Figure 1. Installation of the TLD-100 near the patient's parotid gland (the white pin)

Before use, TLD-100 was calibrated by annealing, which is a heating process to clear the TLD-100 of previously measured radiation. Calibrated TLD-100 was placed near the patient's parotid gland, a salivary gland located in the cheek near the ear (Figure 1). Radiation exposure was administered based on the patient's BMI category. After radiation exposure, the patient's saliva was collected again using the same method. The TLD-100 was then stored for processing at PRTKMMN BRIN

2.3 Measurement of Salivary pH

Before being used to measure the pH of the patient's saliva, the digital pH meter was calibrated using buffer solutions of pH 6.86, 4.01, and 9.18. Calibration is performed by washing the electrode sensor in running water, then dried. After drying, the "ON/OFF" button on the front of the pH meter is pressed. Then, the pH meter was dipped into a pH 6.86 buffer solution. The buffer solution is made by dissolving the buffer powder in 250 mL of distilled water. The "CAL" button on the front of the pH meter is pressed for 5 seconds, then released. The pH meter screen blinked 3 times with the number 6.86 displayed. The same procedure was carried out for pH 4.01 and 9.18 buffer solutions. The pH of the patient's saliva before and after radiation exposure was measured by inserting a digital pH meter into a container of saliva until the pH meter showed stable measurement results.

2.4 Amylase Enzyme Activity Test

The test of amylase enzyme activity was carried out with the iodine test. The iodine can determine whether the amylum is hydrolyzed after reacting by saliva, which is marked by a change in color from solid blue to translucent, and measure the absorbance of the solution to determine the activity of the amylase enzyme. The first thing to do was to make a 1% amylum solution by weighing 1 g of amylum powder, mixing it into 10 mL of distilled water, and stirring it with a stir bar until it was well mixed. A total of 70 mL of equivalent solvent was heated to boiling using a hot plate. The mixture of amylum powder and aquades that had been made previously was added to the 70 mL of boiling solvent. The solution was then stirred until all the amylum powder dissolved and became a clear solution. The solution was put into a 100-mL volumetric flask. Distilled water was put into the flask until it reached the limit indicated on it, then homogenized.

A total of 4 mL of 1% amylum solution was put into a test tube. An iodine solution of 0.5 mL was added to the test tube to indicate the presence of amylum in the test solution. Then, 1 mL of patient saliva was homogenized into the test tube. The 1% amylum solution and saliva were allowed to react for 10 minutes at room temperature. After that, the reaction was stopped by adding 2 mL of 1 N HCl and homogenized (Munawaroh et al., 2020).

After being homogenize, the test solution was put into a cuvette until it was filled to ¾ of the cuvette. It was then inserted into a UV-Vis spectrophotometer (Shimadzu UV-1280, USA) at a maximum wavelength of 615 nm to measure the absorbance value. The absorbance value data (A) of the test solution before reacting with saliva and absorbance value data of the test solution after reacting with saliva for 10 minutes were entered into Microsoft Excel.

2.5 Data Processing and Analysis

The change in pH of the patient's saliva was obtained by calculating the absolute value of the difference between the pH of the saliva before and after radiation exposure. The difference between the absorbance value data of the test solution before reacting with saliva and the absorbance value data of the test solution after reacting with saliva for 10 minutes was calculated to obtain the absorbance value of the mass of amylum hydrolyzed by the saliva for 10 minutes (ΔA). The ΔA value was inputted into the linear regression equation on the standard curve of the amylum solution to determine the mass of amylum in grams hydrolyzed by the saliva for 10 minutes. The standard curve of the amylum solution was made by diluting 1% into smaller concentrations and measuring its absorbance value, as seen in Figure 2.

The mass of the amylum hydrolyzed for 10 minutes was then divided by 10 to determine the mass of amylum in grams hydrolyzed by the test saliva for 1 minute (U). The mass of the amylum hydrolyzed by the test saliva for 1 minute was then inputted into equation (1) to obtain the activity of the amylase enzyme (Yoo et al., 1987).

$$K = \frac{U}{E} \quad (1)$$

In equation (1), K is the value of amylase enzyme activity (units/mL), U is the mass of starch in grams hydrolyzed in 1 minute (units), and E is the volume of saliva (mL).

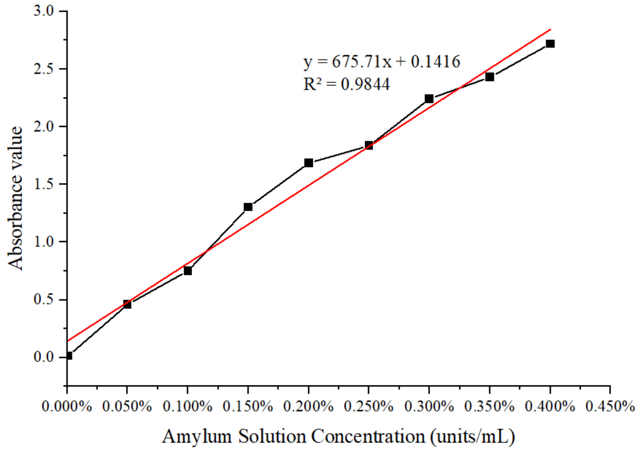

Figure 2. The standard curve of the amylum solution

The absorbed radiation dose was obtained from the TLD-100 reading on the TLD reader at PRTKMMN BRIN. The readings were taken twice on each TLD chip. The TLD-100 reading on the patient is the total intensity TL_{total} and the reading of the TLD-100 background is the background intensity $TL_{background}$. The net of intensity TL_{net} is obtained by subtracting TL_{total} from $TL_{background}$. The absorbed dose the patient received is obtained based on equation (2) (Akhadi, 2020).

$$D = TL_{net} \times F_K \times F_{KE} \quad (2)$$

The equivalent dose is obtained based on equation (3) and the effective dose received by the patient's parotid gland is obtained based on equation (4).

$$H_{T,R} = W_R \times D \quad (3)$$

$$H_E = W_T \times H_{T,R} \quad (4)$$

In equations (2), (3), and (4), D is the absorbed dose (mGy), TL_{net} is the TLD-100 net reading (nC), F_K is the calibration factor (mGy/nC), F_{KE} is the energy correction factor, $H_{T,R}$ is the equivalent dose (mSv), W_R is the weight factor of radiation, H_E is the effective dose (mSv), and W_T is the weight factor of the tissue or organ.

3. RESULTS AND DISCUSSION

The dental panoramic's voltage, current, and exposure time were adjusted based on the patient's BMI. Underweight patients were coded 1-10. Normal-weight patients were coded 11-20. Overweight patients were coded 21-30.

3.1 The Correlation of Radiation Dose and Salivary pH to Patients

Based on the effective dose and salivary pH measurements that have been done, the effective dose of radiation received by the parotid gland in each patient is different. This is due to the different voltage, current, and exposure times given to the patient during the examination. The results of effective dose and salivary pH measurements can be seen in Figure 3.

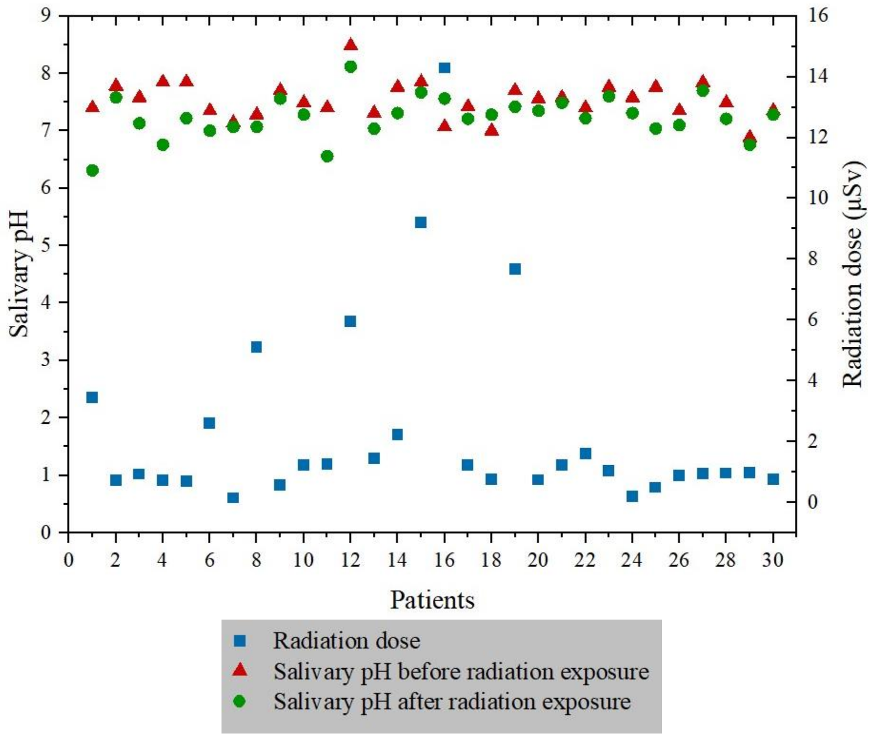

Figure 3. Effective dose and salivary pH of the patient

The difference in effective dose value occurs because the exposure factor is in accordance with the patient's BMI that can be seen in Figure 3. The results of this study show that patients who are given high voltage do not mean that the radiation dose received will also be greater, and vice versa. This can occur due to variations in voltage values that are similar (Naserpour et al., 2019). The results of this research are similar to the effects of research conducted by Omidi, et al. (2022), irradiation in patients with a voltage of 63.8 kV has an average radiation dose received by the parotid gland of (326±26) μGy, irradiation with a voltage of 65.4 kV has an average radiation dose of (266±25) μGy, and irradiation with a voltage of 68.6 kV has an average radiation dose of (307±17) μGy.

Some patients have higher parotid gland radiation dose values compared to other patients, which the patient's position during irradiation can cause, such as patient movement. This is similar to the results of research conducted by Naserpour, et al. (2019), states that the radiation dose received by patients can be influenced by the location of the organ and the position of the patient who moves during irradiation.

Based on the pH value of saliva before and after performing dental panoramic examinations, it is found that radiation affects changes in the pH of the patient's saliva. After radiation, there was a decrease in salivary pH in 28 patients and an increase in salivary pH in 2 patients. The decrease in salivary pH occurs because during the dental panoramic examination, ionizing radiation hits the parotid gland, which is sensitive to radiation. The parotid gland comprises serous acinar cells with high water content and is reactive to ionizing radiation. Ionizing radiation causes changes in water molecules (H_2O). Ionization of water molecules occurs if the required ionization energy is sufficient, which is 12.6 eV or 2.0117×10-18 V, and the voltages used in irradiation are 72 kV, 73 kV, and 76 kV, so it is able to ionize water molecules. The ionization of water molecules change them into hydrogen free radicals (H^+) and hydroxyl free radicals (OH^-) (Syaifudin, 2023). Free radicals can cause damage to serous acinar cells indirectly. Damage to acini serus cells leads to a decrease in salivary rate, changes in salivary quantity and quality that affect salivary pH. Salivary pH is influenced by salivary flow rate. A decrease in salivary rate will affect the buffer capacity, and a decrease in bicarbonate concentration, so it becomes acidic and decreases in salivary pH. The results of this research are similar to the results of study conducted by Susanti et al. (2016) and Nurgalih et al. (2019) state that the decrease in salivary pH occurs due to highly reactive free radicals, so the lower the bicarbonate ions, the higher the hydrogen ions, which means the lower the salivary pH.

The increase in salivary pH in 2 patients can be caused by plaque buildup on the teeth; the results of this study are similar to the effects of research conducted by Amatulhaq et al. (2022) states that dental plaque contains calcium (Ca) salts, which when interacting with ionizing radiation, will also be ionized into Ca^{2+} ions with the minimum energy required is 6.1132 eV or 9.7985×10^{-19} V. The ionization of calcium can occur because the energy used during radiation exposure has exceeded the minimum energy required. OH^- ions will interact with Ca^{2+} ions to form $Ca(OH)_2$ or calcium hydroxide. Calcium hydroxide is a strong base, so that it will increase saliva's pH.

Based on the values of radiation dose and salivary pH of patients, the relation between radiation dose and salivary pH can be seen in Figure 4. Figure 4 shows that radiation dose affects changes in salivary pH in patients.

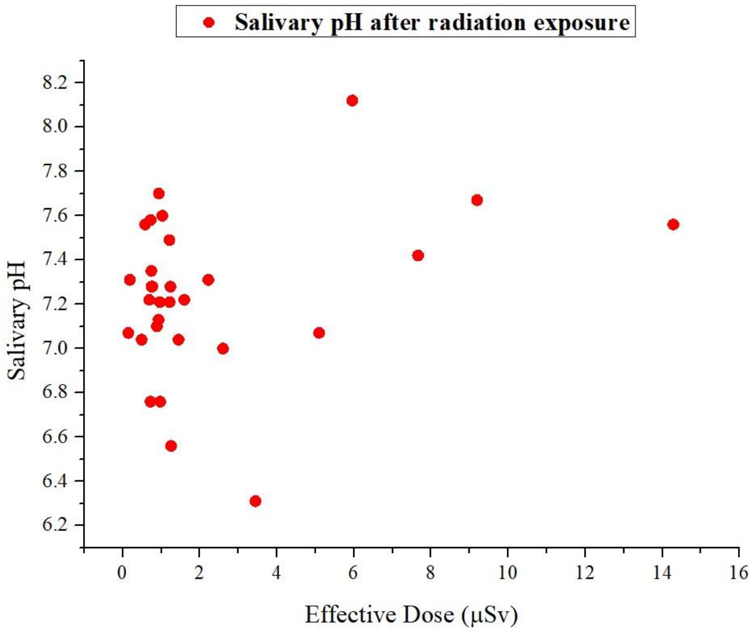

Figure 4. Relation between an effective dose and salivary pH

Differences in salivary pH after radiation exposure ranged from pH 6.31-8.12, not much different from salivary pH before radiation exposure with a range of 6.88 to 8.48 that can be seen in Table 1. The average decrease in salivary pH in 28 patients was 0.34 and the increase in salivary pH in 2 patients had an average of 0.385. Whether there is a difference in salivary pH in patients before and after radiation exposure from dental panoramic, then t-test was conducted. The result obtained is 0.00138 which shows the data significance value is smaller than 0.05 (P-value < 0.05). So, it can be seen that there is a significant difference between pH before and after radiation exposure. Based on the results of this study, it cannot be seen how much the dose of radiation received by patients affects the value of salivary pH changes after radiation exposure. This could be due to the minimal dose of radiation the patient receives and changes in salivary pH can affect the activity of the amylase enzymes.

3.2 The Correlation between Changes in Salivary pH and Amylase Enzyme Activity of Patients

The correlation between changes in salivary pH and the activity of amylase enzyme can be seen in Figure 5. Based on Figure 5, it can be seen that the activity of amylase enzyme is affected by the pH value of saliva . For example, in patient 1, the pH value before radiation exposure can be seen in the orange coloured dot and the pH of saliva after radiation exposure has decreased which can be seen in the purple coloured dot. In contrast, the activity of amylase enzyme before radiation exposure can be seen in the pink coloured dot. The activity of the amylase enzyme after exposure to radiation has increased which can be seen in grey dots.

Table 1 Salivary pH before and after radiation exposure

Patient's Code	Salivary pH	
	Before Radiation Exposure	After Radiation Exposure
1	7.40	6.31
2	7.78	7.58
3	7.58	7.13
4	7.85	6.76
5	7.85	7.22
6	7.35	7.00
7	7.14	7.07
8	7.28	7.07
9	7.70	7.56
10	7.49	7.28
11	7.40	6.56
12	8.48	8.12
13	7.31	7.04
14	7.76	7.31
15	7.85	7.67
16	7.07	7.56
17	7.42	7.21
18	7.00	7.28
19	7.70	7.42
20	7.56	7.35
21	7.58	7.49
22	7.40	7.22
23	7.76	7.60
24	7.58	7.31
25	7.76	7.04
26	7.35	7.10
27	7.84	7.70
28	7.49	7.21
29	6.88	6.76
30	7.35	7.28

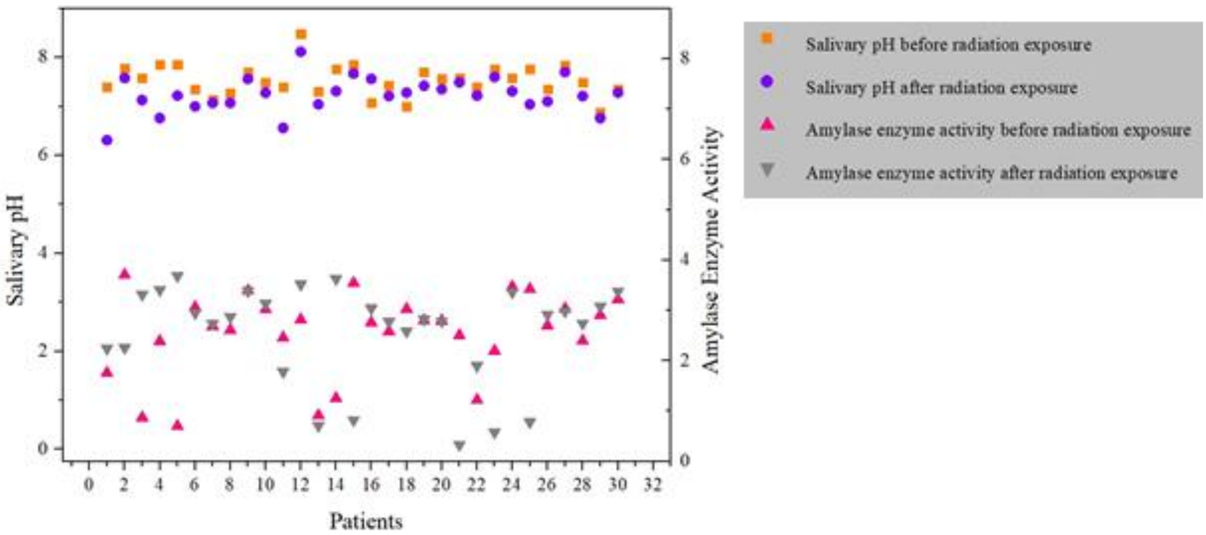

Figure 5. The relation between changes in salivary pH and amylase enzyme activity

Changes in the pH value of saliva result in changes in the activity of the amylase enzyme, because the amylase enzyme works well as an accelerator of chemical reactions (catalyst) at the normal pH of the mouth, which is 6.8-7 (Tatah & Otitoju, 2015; Wahyuni, 2017). Salivary pH outside the average pH decreases the work activity of the amylase enzyme, because if the pH of saliva is too acidic or alkaline it can damage the structure of the amylase enzyme. An acidic salivary pH value is when the salivary pH is less than 6.8, and an alkaline salivary pH is when the salivary pH is greater than 7.

Table 2 The Correlation between Salivary pH and Amylase Enzyme Activity Before and After Radiation Exposure

Patient's Code	Salivary pH		Amylase Enzyme Activity ($\times 10^{-4}$ unit/mL)	
	Before Radiation Exposure	**After Radiation Exposure**	**Before Radiation Exposure**	**After Radiation Exposure**
1	7.40	6.31	1.557	2.058
2	7.78	7.58	3.559	2.068
3	7.58	7.13	0.644	3.156
4	7.85	6.76	2.206	3.251
5	7.85	7.22	0.470	3.536
6	7.35	7.00	2.899	2.778
7	7.14	7.07	2.508	2.561
8	7.28	7.07	2.432	2.700
9	7.70	7.56	3.236	3.230
10	7.49	7.28	2.852	2.972
11	7.40	6.56	2.277	1.580
12	8.48	8.12	2.644	3.364
13	7.31	7.04	0.687	0.478
14	7.76	7.31	1.038	3.475
15	7.85	7.67	3.393	0.591
16	7.07	7.56	2.587	2.875
17	7.42	7.21	2.404	2.605
18	7.00	7.28	2.863	2.405
19	7.70	7.42	2.627	2.647
20	7.56	7.35	2.622	2.613
21	7.58	7.49	2.323	0.088
22	7.40	7.22	1.003	1.700
23	7.76	7.60	2.007	0.343
24	7.58	7.31	3.321	3.203
25	7.76	7.04	3.268	0.554
26	7.35	7.10	2.524	2.747
27	7.84	7.70	2.870	2.815
28	7.49	7.21	2.213	2.565
29	6.88	6.76	2.737	2.913
30	7.35	7.28	3.057	3.224

Based on the changes in salivary pH and amylase enzyme activity, 56.67% of patients experienced an increase in amylase enzyme activity, and 43.33% experienced a decrease in amylase enzyme activity which can be seen in Table 2. The rise in amylase enzyme activity occurred in patients who underwent a decline in salivary pH after radiation exposure, with an average salivary pH of 7.17. The average pH value of 7.17 is close to the standard pH value of the mouth, so the activity of the amylase enzyme can work better than before radiation exposure. Patients who experienced a decrease in amylase enzyme activity occurred when the average pH of saliva after radiation exposure was 7.32. The pH value of 7.32 is more alkaline than that of patients with increased amylase enzyme activity. The decrease in amylase enzyme activity can be caused by the precipitate formed when the starch solution reacts with saliva, which also affects the value of amylase enzyme activity. In the results of this research, the more precipitate, the more concentrated the solution, which results in a more excellent absorbance value. A considerable absorbance value will produce a small amylase enzyme activity value. Therefore, the results showed that the slightest change in salivary pH would affect the activity of the amylase enzyme. Other factors that can affect the activity of amylase enzymes are substrate concentration, enzyme concentration, and the presence of activators and inhibitors.

The results of this research are similar to the effects of a study conducted by Amatulhaq et al. (2022) states that out of 20 patients, ten patients experienced an increase in amylase enzyme activity, and ten patients experienced a decrease in amylase enzyme work activity. This happens because the slightest change in pH also affects changes in the activity of amylase enzymes. The results of this research are also similar to the effects of the study by Syauqy et al. (2018) states that salivary pH affects the activity of amylase enzymes in catalyzing a reaction. This is because the concentration of hydrogen ions affects the structure and activity of enzymes. Suppose the concentration of hydrogen ions changes from the optimum condition. In that case, the enzyme can be damaged, which results in decreased enzyme activity and can cause the enzyme to become non-functional.

3.3 The Relation of Radiation Dose to Amylase Enzyme Activity

The relation of radiation dose to amylase enzyme work activity can be seen in Figure 6. Based on Figure 6, it can be seen that the radiation dose received by the parotid gland affects the work activity of the amylase enzyme, because any dose can have biological effects on humans. The amylase enzyme activity value of patients after radiation exposure increased in 17 patients and decreased in 13 patients. Patients who experienced an increase in amylase enzyme activity because the pH of saliva after radiation exposure was approaching the optimum pH of the mouth. The other patients who experienced a decrease in amylase enzyme activity because the pH of saliva after radiation exposure was alkaline. This occurs because radiation doses can have biochemical effects caused by ionizing radiation, resulting in changes in salivary pH which also affect the activity of amylase enzymes. Other factors that may interfere the activity of amylase enzymes are salivary quality, such as microbes in saliva, patient metabolism, and salivary temperature, which can affect the interaction of matter with radiation.

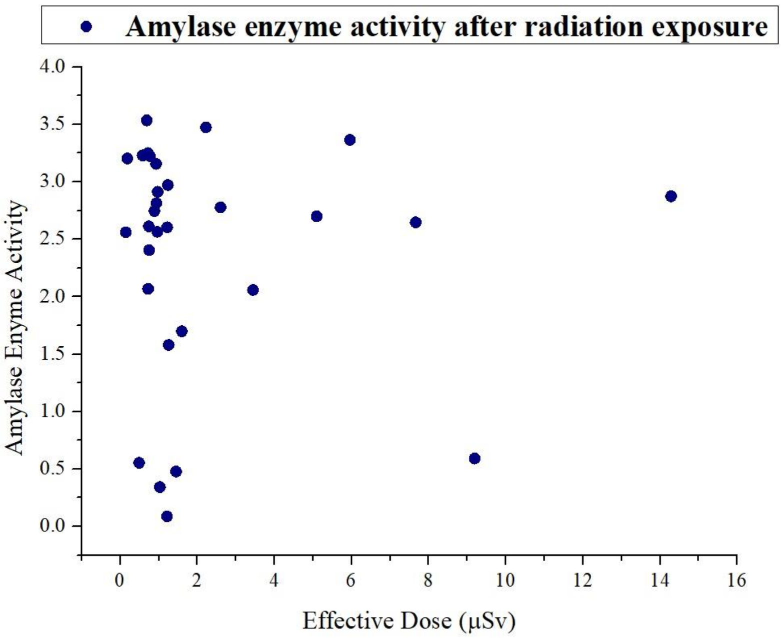

Figure 6. The relation between the effective dose and amylase enzyme activity

The activity of amylase enzymes depends on salivary pH to work (Sitompul et al., 2022) optimally. The results of this research it has yet to be found how much radiation dose affects the magnitude of changes in the work activity of amylase enzymes in saliva, because the radiation dose received by the parotid gland is minimal. The results of this research are similar to the effects of a study conducted by Amatulhaq et al. (2022) states that the value of the patient's amylase enzyme work activity depends on salivary pH. Radiation doses do not always adversely affect the work activity of amylase enzymes. When the work activity of the amylase enzyme increases, the process of breaking down carbohydrates in the mouth can take place quickly, while a decrease in the work activity of the amylase enzyme causes the breakdown of carbohydrates in the mouth to be incomplete and can interfere with the digestive process. When the pH of saliva is away from the optimum pH, it can have an impact on changing the shape or structure of the amylase enzyme, so it cannot bind to its substrate. Salivary pH that is very acidic or alkaline can make the amylase enzyme become damaged and unable to work properly. Amylase enzymes that cannot work properly can cause incomplete breakdown of carbohydrates, so digestive disorders can occur. Therefore, patients after a panoramic dental examination are advised to practice a healthy lifestyle, such as eating nutritious foods and getting enough rest, so that the amylase enzyme can work optimally.

4. CONCLUSION

Based on the analysis of radiation dose, salivary pH, and amylase enzyme activity in the dental panoramic examination of 30 patients, several noteworthy conclusions can be drawn. The data indicates that the radiation dose, averaging 2.33 μSv, has a discernible impact on salivary pH. The radiation led to a decrease in salivary pH in 28 patients, with an average reduction of 0.34. This can be attributed to the detrimental effects of free radicals on serous acinus cells within the parotid glands, resulting in a decreased salivary flow rate and increased bicarbonate ion concentration, making the saliva more alkaline. In 2 patients, radiation exposure causes an increase in salivary pH, averaging 0.385. This is due to the interaction of hydroxyl free radicals with calcium salt content in dental plaque. Furthermore, changes in salivary pH affect amylase enzyme activity. Seventeen patients exhibit increased amylase enzyme activity, averaging 0.75×10^{-4} unit/mL, as their salivary pH approaches the optimum pH for oral digestion. Conversely, 13 patients experienced decreased amylase enzyme activity, averaging 0.96×10^{-4} unit/mL, due to alkaline saliva and sediment formation, indicating a direct connection between radiation dose, salivary pH, and amylase enzyme activity. In practical terms, alterations in amylase enzyme activity, prompted by changes in radiation dose and salivary pH, could lead to incomplete carbohydrate breakdown, potentially resulting in digestive issues. Mitigation of these issues can be achieved through adopting a healthy lifestyle after a dental panoramic examination and maintaining proper oral health, ensuring the maintenance of salivary quality. Future research should consider other factors impacting salivary pH and amylase enzyme activity for a more comprehensive understanding.

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