

DENTAL X-RAY RADIATION EXPOSURE IN RADIOPROTECTION CASES AND DENTAL IMAGES REPEATABILITY FACTORS

Asmiati Amir¹⁾, Muhammad Yunus^{*2)}, Septiana Kurniasari³⁾, Citron Supu Payu⁴⁾

¹⁾Study Program of Radiology, Politeknik Kesehatan Muhammadiyah Makassar

^{2,3)}Study Program of Physics, FMIPA, Universitas Negeri Gorontalo

⁴⁾Study Program of Science Education, FMIPA, Universitas Negeri Gorontalo

**Corresponding author*

e-mail: asmiati.amir@poltekkesmu.ac.id¹⁾, muhammad.yunus@ung.ac.id^{*2)},
septiana@ung.ac.id³⁾, citron.payu@ung.ac.id⁴⁾

** Corresponding author*

Received: Dec. 15th, 2023; Revised: Dec. 22th, 2023; Accepted: Dec. 28th, 2023; Published: Jan. 04th, 2024

ABSTRACT

This research was carried out using a literature review method to determine radioprotection cases and repeatability factors of dental images on dental X-rays. Determination of the repeatability factor for dental photographs using data over three months obtained at Rajawali Citra Hospital, RSUD Dr. Tjitrowardojo Purworejo, and RSUD Muntilan Magelang. Case A, case B, and case C produce high percentage values. This is because dental practitioners consider the provision of protection in reducing the scattered dose of dental X-rays for patients to be often overlooked. Determination of X-ray radiation exposure given by a radiographer does not have significant differences for each patient, such as thin, standard, and obese. Meanwhile, the data on the repeatability percentage value of dental images exceeds the Hospital Minimum Service Standard indicator limit by the Decree of the Minister of Health Number 129 of 2008 concerning the incidence of X-ray service failure, which has an image failure standard of $\leq 2\%$. The highest position factor was obtained at Hospital-2 at 75%, and the lowest was obtained at Hospital-1 at 50%. Meanwhile, the highest exposure factor was obtained at Hospital-1 at 39% and the weakest at Hospital-2 at 25%. Position errors made by the radiographer cause position factors, and exposure errors are caused by exposure factors that are too high or low.

Keywords: dental; radioprotection cases; repeatability factors; X-ray

INTRODUCTION

X-ray is a medical technology that can emit X-rays using microwaves and light to provide a visual image. X-rays can penetrate flesh tissue but cannot penetrate bones (Yunus et al., 2022; Amir et al., 2021). One example of the application of this technology is dental panoramic radiograph (DPR) images (Chen et al., 2022; Lin et al., 2021; Bunga, 2013). In dental practice, X-ray technology generally involves using conventional radiography, CT scans, Cone Beam Computerized Tomography (CBCT), and Dental X-ray Imaging (DXRI) (Villarraga

et al., 2019; Genisa et al., 2015; Kumar et al., 2021).

X-ray modalities in the examination produce radiographic images that show radiolucent and radiopaque images on the radiograph. Radiograph images can be observed using a computer monitor, transferred using computer networks and the internet, and printed using paper or other media. The application of CBCT has replaced CT in dental practice because CBCT machines have smaller dimensions and are more affordable than conventional CT machines (Widyaningrum et al., 2018).

CBCT is a machine that can be used to monitor dental health. Teeth are divided into two main parts: the crown and the root (Ozcan et al., 2016). The tooth crown is covered by enamel, while the tooth root is protected by cementum. These two layers meet at the neck of the tooth. Clinically, the tooth crown is visible to the human eye, namely the part of the tooth above the gum attachment area (Satpathy et al., 2019). In contrast, tooth roots are invisible to the human eye. The mandibular bone is the jaw bone where the teeth are attached (Jacobs, 2011; Wilianti & Agoes, 2019).

Dental radiographic examinations that utilize X-ray ionizing radiation can have several negative consequences, including potential damage to DNA. The impact of X-ray radiation on DNA can cause cell damage which can cause cell death which consists of two processes, namely apoptosis and necrosis (Saputra & Astuti, 2012). The use of X-rays in the medical realm involves panoramic radiography techniques, where the implementation is related to the use of low-dose X-ray radiation, which will display a more comprehensive image of the mandibular and maxillary areas in one film (Susanti et al., 2016).

The impact of radiation is divided into two types, namely deterministic effects and stochastic effects. Deterministic effects are related to cell death and depend on a specific threshold dose (Scott, 2005). Meanwhile, stochastic effects are effects that appear without taking into account the size of the exposure dose. Protection against the effects of exposure to X-ray ionizing radiation needs to be provided to exposed patients and health personnel. This

protection aims to control and monitor diagnostic quality and radiation-related risks (Linet et al., 2012). In addition, it is essential to know that dose limits for occupational and community exposure aim to ensure that no individual receives a very high radiation dose (Susanto et al., 2021). So, the author will examine dental X-ray radiation exposure through several literature reviews on cases of radioprotection for dental practitioners patients, radiation dose on the quality of dental X-rays, and dental image repeatability factors involving position factors and exposure factors.

METHOD

This research used data collection methods from several literature reviews by examining article sources regarding dental X-ray radiation exposure. The data studied are cases of protecting the safety of radiation workers, administering radiation doses to the quality of dental X-rays, dental images repeatability factors involving position factors and exposure factors in dental X-rays. Determining the dental images repeatability factor using data over three months obtained at several hospitals, namely Rajawali Citra Hospital, RSUD Dr. Tjitrowardojo Purworejo, and RSUD Muntilan Magelang.

RESULTS AND DISCUSSION

Implementing dental X-ray radiation exposure to monitor dental health produces information in a CBCT and DXRI dental images, as in Figure 1.

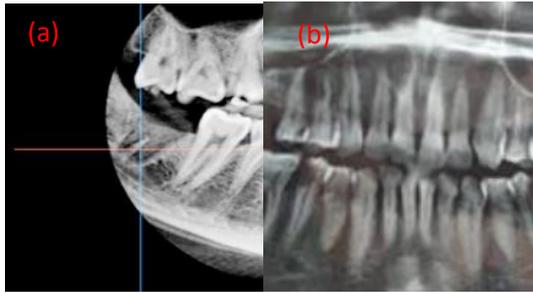


Figure 1. Dental image results: (a) CBCT (Widyaningrum et al., 2018) and (b) DXRI (Sumijan, 2022).

Based on Figure 1 is a CBCT and DXRI dental image. CBCT is a digital imaging method that resembles a dental panoramic machine for recording photos of objects in the field of view (FOV). The CBCT machine rotates around the patient's head using cone-shaped X-rays to produce object information in the form of three-dimensional images (Widyaningrum et al., 2018). Meanwhile, DXRI is an imaging technique related to tooth growth, soft tissue, tooth loss, bone framework, fangs, and the implementation of root canal treatment. This technique has a crucial role in detecting possible abnormalities in the tooth structure that cannot be observed during a clinical examination by a dentist (Sumijan, 2022).

Data on the percentage of Radioprotection cases for dental practitioners for patients is seen in Figure 2. In recording dental images, paying attention to protection between radiation workers and patients is essential. Several cases of radioprotection for dental practitioners for patients include Case A (position and distance rules), Case B (no protection for the patient), and Case C (reduction of radiation exposure).

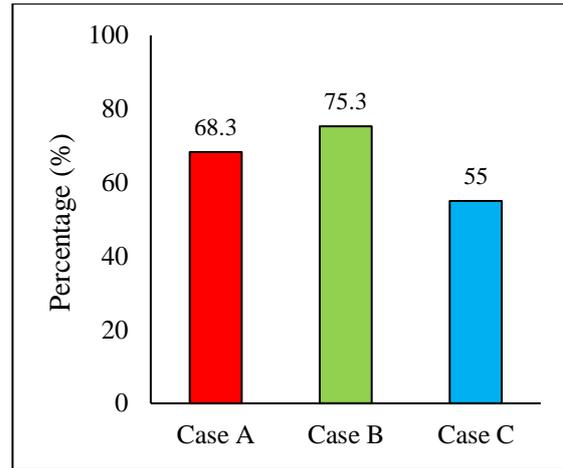


Figure 2. Radioprotection cases for dental practitioners for patients (Susanto et al., 2021).

Based on Figure 2 is a graph comparing the percentage values for several cases of radioprotection. Case B has the highest percentage rate of 75.3%. This value is relatively high because dental practitioners consider protecting to reduce the scattered dose of dental X-rays for patients, which is often neglected. The second highest percentage value is case A, which has a value of 68.3%. This case is a case of rules between position and distance that are classified as high, where the position and distance rules based on national standards can state that the percentage value is inappropriate and unacceptable. Meanwhile, the third highest percentage is case C. This case compares digital images to film, reducing radiation exposure by 55% (Susanto et al., 2021).

The determination of X-ray radiation exposure from dental panoramic aircraft can be adjusted by considering patient category factors, namely thin, standard, and obese. The radiation dose value influences the quality of the X-ray image. Patient category data regarding voltage, current strength and time values can be seen in Figure 3.

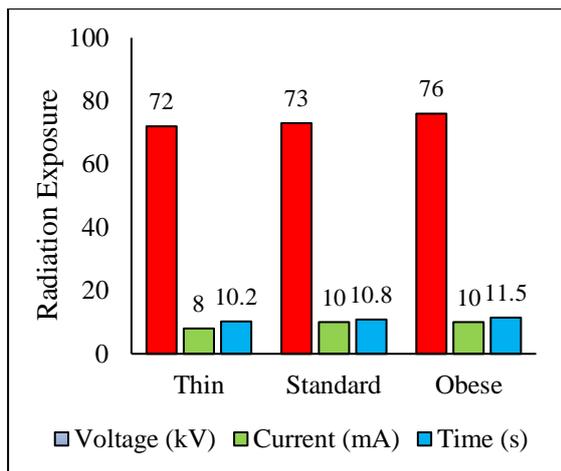


Figure 3. Patient categories to variation values of voltage, current, and time (Rasyada et., 2023).

The graph in Figure 3 shows the comparative values of voltage, current strength, and time that must be given to patient categories. The greater the patient's weight, the greater the tension that must be applied. Likewise, the current strength and time produced will increase as body weight increases. The radiation dose value influences the quality of the X-ray image made from a panoramic dental aircraft, but voltage variations do not affect the radiation dose. The current strength and exposure time also greatly influence the quality and amount of X-rays scattered. The largest values for voltage, current strength and time were found in the overweight patient category, namely voltage 76 kV, 10 mA and 11.5 s. This is caused by the voltage, current and time settings that have been determined on the dental panoramic equipment so that the voltage given by the radiographer does not have significant differences for each patient, such as thin, standard, and obese (Rasyada et., 2023).

In carrying out his duties, a radiographer must be aware of various error factors in handling patients, which

can cause dental image repeatability factors. Data on a repeat of dental images presented from the literature review, as shown in Figure 4, is data from several hospitals such as Hospital-1 is Rajawali Citra Hospital (Iskardyani, 2021), Hospital-2 is RSUD Dr. Tjitrowardojo Purworejo (Kurniawan, 2017), and Hospital-3 is RSUD Muntilan Magelang (Manurung et al., 2018).

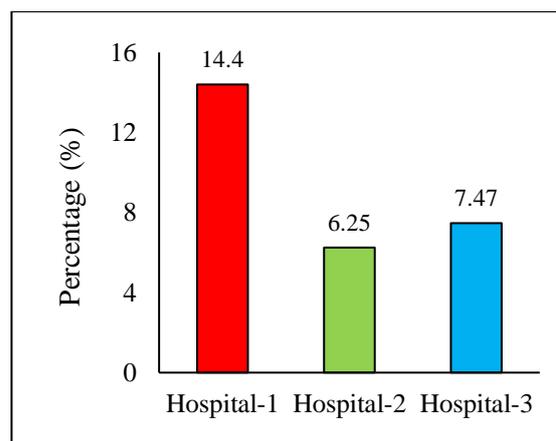


Figure 4. Comparison of the percentage of dental image repeatability factors (Iskardyani, 2021; Kurniawan, 2017; Manurung et al., 2018).

The comparative value of the percentage of dental image repeatability, as shown in the graph in Figure 4, produces the smallest value at Hospital-2 at 6.25% and the highest at Hospital-1 at 14.4%. These values exceed the limits of the Hospital Minimum Service Standards indicators by the Decree of the Minister of Health Number 129 of 2008 concerning the incidence of X-ray service failure, which has a standard for photo failure $\leq 2\%$ (Menteri Kesehatan RI, 2008). This considerable repeatability factor percentage value occurs due to exceeding the threshold for rejection of intra-oral dental radiographs, so it can be stated that the service time provided by the hospital is more prolonged, and there is an increase in

the dose received by the patient (Iskardyani, 2021).

The factors influencing the repeatability of dental radiographs are based on the percentage of patient position factors and exposure factors, as seen in Figure 5.

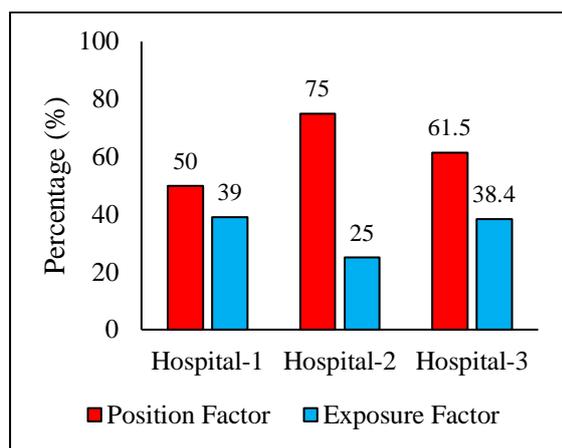


Figure 5. Comparative value of the percentage of position factor and exposure factor (Iskardyani, 2021; Kurniawan, 2017; Manurung et al., 2018).

The percentage comparison of position factor and dental X-ray exposure factor based on the graph in Figure 5 shows varying values. The position factor is caused by a position error made by the radiographer. Position errors include mistakes in dental film placement, patient position, X-ray source, collimation and incorrect image reception and can eliminate the anatomical image you want to see. The highest position factor was obtained at Hospital-2 at 75%, and the lowest was obtained at Hospital-1 at 50%. Meanwhile, the highest exposure factor was obtained at Hospital-1 at 39% and the weakest at Hospital-2 at 25%. Exposure errors are caused by exposure factors that are too high or low, resulting in radiographs that are too black or white (Iskardyani, 2021).

CONCLUSION

Radioprotection cases for dental practitioners patients produce a high percentage value in cases A, B, and C. This is because dental practitioners consider that protection by reducing the scattered dose of dental X-rays for patients is often neglected. Determination of X-ray radiation exposure given by a radiographer does not have significant differences for each patient, such as thin, average, and obese. Meanwhile, the data on the percentage value of repeatability factors of dental images exceeds the Minimum Hospital Service Standard indicator limit by the Decree of the Minister of Health Number 129 of 2008 concerning the incidence of X-ray service failure, which has a photo failure standard of $\leq 2\%$.

REFERENCES

- Amir, A., Yunus, M., Latief, M. F., & Ramadani, A. I. W. S. (2021). X-Ray Technology to Evaluate Mortality of Covid-19 Patients in Comorbid Diabetes Mellitus and Stroke. *Dewantara Journal of Technology*, 2(2), 53-56. <https://doi.org/10.59563/djtech.v2i2.127>
- Bunga, Y. K. (2013). *Segmentasi Foramen Mental dengan Histogram Thresholding Menggunakan Discriminant Analysis pada Citra Dental Panoramic Radiograph*. Disertasi. Universitas Islam Negeri Maulana Malik Ibrahim. <http://etheses.uin-malang.ac.id/7579/>
- Chen, S. L., Chen, T. Y., Huang, Y. C., Chen, C. A., Chou, H. S., Huang, Y. Y., ... & Chiang, W. Y. (2022). Missing teeth and restoration

- detection using dental panoramic radiography based on transfer learning with CNNs. *IEEE Access*, 10, 118654-118664. <https://doi.org/10.1109/ACCESS.2022.3220335>
- Genisa, M., Rajion, Z. A., Mohamad, D., Pohchi, A., Kadir, M. R. A., & Shuib, S. (2015). Effect of Different Angle Scanning on Density Estimation Based on Hounsfield Unit on CT and CBCT. *Sains Malaysiana*, 44(9), 1331-1337. <https://doi.org/10.17576/jsm-2015-4409-16>
- Iskardyani, D. (2021). Analisis Faktor Pengulangan Foto Dental di Instalasi Radiologi Rumah Sakit Rajawali Citra Bantul. *Jurnal Medika Radiologi*, 3(1), 19-23. <http://jmr.jurnalsenior.com/index.php/jmr/article/view/24#>
- Jacobs, R. (2011). Dental cone beam CT and its justified use in oral health care. *Journal of the Belgian Society of Radiology*, 94(5), 254-265. <https://doi.org/10.5334/jbr-btr.662>
- Kumar, A., Bhadauria, H. S., & Singh, A. (2021). Descriptive analysis of dental X-ray images using various practical methods: A review. *PeerJ Computer Science*, 7, e620. <https://doi.org/10.7717/peerj-cs.620>
- Kurniawan, E. (2017). *Faktor-Faktor Penyebab Pengulangan Radiografi Gigi Geligi Intra Oral di Instalasi Radiologi RSUD dr. Tjitrowardoyo Purworejo*. Tugas Akhir DIII. Purwokerto: Jurusan Teknik Radiodiagnostik dan Radioterapi. <https://repository.poltekkes-smg.ac.id/>
- Lin, S. Y., & Chang, H. Y. (2021). Tooth numbering and condition recognition on dental panoramic radiograph images using CNNs. *IEEE Access*, 9, 166008-166026. <https://doi.org/10.1109/ACCESS.2021.3136026>
- Linnet, M. S., Slovis, T. L., Miller, D. L., Kleinerman, R., Lee, C., Rajaraman, P., & Berrington de Gonzalez, A. (2012). Cancer risks associated with external radiation from diagnostic imaging procedures. *CA: a cancer journal for clinicians*, 62(2), 75-100. <https://doi.org/10.3322/caac.21132>
- Manurung, D., Utama, H. N., & Rosidah, S. (2018). Analisa Penolakan Foto Gigi Intra Oral Di Instalasi Radiologi Rumah Sakit Umum Daerah Muntilan Kabupaten Magelang. *Jurnal Ilmu dan Teknologi Kesehatan*, 5(1). <https://doi.org/10.33666/jitk.v5i1.92>
- Menteri Kesehatan RI. (2008). Surat Keputusan Menteri Kesehatan No. 129 Tentang Standar Pelayanan Minimal Rumah Sakit. <https://www.regulasip.id/book/9233/read>
- Ozcan, G., Sekerci, A. E., Cantekin, K., Aydinbelge, M., & Dogan, S. (2016). Evaluation of root canal morphology of human primary molars by using CBCT and comprehensive review of the literature. *Acta Odontologica Scandinavica*, 74(4), 250-258. <https://doi.org/10.3109/00016357.2015.1104721>

- Rasyada, L. A., Milvita, D., & Nuraeni, N. (2023). Efektivitas Kacamata Pb pada Pemeriksaan Gigi Menggunakan Pesawat Dental Panoramic Berdasarkan Laju Dosis Radiasi. *Jurnal Fisika Unand*, 12(4). <https://doi.org/10.25077/jfu.12.4.608-614.2023>
- Saputra, D., & Astuti, E. R. (2012). Apoptosis dan nekrosis sel mukosa rongga mulut akibat radiasi sinar-x dental radiografik konvensional. *Dentomaxillofacial Radiology Dental Journal*, 3(1), 36-40. <http://repository.unair.ac.id/id/eprint/108115>
- Satpathy, A., Ranjan, R., Priyadarsini, S., Gupta, S., Mathur, P., & Mishra, M. (2019). Diagnostic Imaging Techniques in Oral Diseases. *Medical Imaging Methods: Recent Trends*, 59-95. https://doi.org/10.1007/978-981-13-9121-7_3
- Scott, B. R. (2005). Stochastic thresholds: a novel explanation of nonlinear dose-response relationships for stochastic radiobiological effects. *Dose-Response*, 3(4), dose-response. <https://doi.org/10.2203/dose-response.003.04.0>
- Sumijan, S. (2022). Pengembangan Ekstraksi dalam Identifikasi Kelainan Gigi pada Citra Dental X-ray imaging (DXRI). *JKTI*, 9(1). <http://repository.upiyptk.ac.id/id/eprint/3745>
- Susanti, N. T., Prasetyarini, S., & Shita, A. D. P. (2016). Pengaruh Paparan Radiasi Sinar-X dari Radiografi Panoramik terhadap pH Saliva. *Pustaka Kesehatan*, 4(2), 352-357. <https://jurnal.unej.ac.id/index.php/JP/K/article/view/3993>
- Susanto, E., Larasati, E., Warsono, H., & Yuniningsih, T. (2021). Protection of the Safety of Dental Health Workers Against Radiation Exposure Dental X-Ray. *Jurnal Kesehatan Gigi*, 8(2). <https://doi.org/10.31983/jkg.v8i2.8100>
- Villarraga-Gómez, H., Herazo, E. L., & Smith, S. T. (2019). X-ray computed tomography: from medical imaging to dimensional metrology. *Precision Engineering*, 60, 544-569. <https://doi.org/10.1016/j.precisioneng.2019.06.007>
- Widyaningrum, R., Faisal, A., Mitrayana, M., Mudjosemedi, M., & Agustina, D. (2018). Imejing diagnostik kanker oral: prinsip interpretasi pada radiograf dental, CT, CBCT, MRI, dan USG. *Maj Kedokt Gigi Indones*, 4(1), 1-14. <https://doi.org/10.22146/majkedgiind.22050>
- Wilianti, A. S., & Agoes, S. (2019). Pengolahan Citra untuk Perbaikan Kualitas Citra Sinar-X Dental Menggunakan Metode Filtering. *Jetri*, 31-46. <https://doi.org/10.25105/jetri.v17i1.4492>
- Yunus, M., Amir, A., Mirnawati, M., Fitriani, F., & Fatimah, S. (2022). Compliance Test of X-Ray Beam Quality Using HVL Parameter on Digital Mammography. *Dewantara Journal of Technology*, 3(1), 26-30. <https://doi.org/10.59563/djtech.v3i1.146>