Simulation artifact for evaluation of dental x-ray radiation field

Artefato de simulação para avaliação do campo de radiação de raios-x dentários

Artefacto de simulación para la evaluación del campo de radiación de rayos-x dentales

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RESUMO

Objetivo: testar o controle de qualidade em aparelhos de raios-X odontológicos intrabucais em consultórios privados no Distrito Federal, cidade do Gama. **Método:** mediram-se os diâmetros dos campos de radiação destes aparelhos, assim evitando que o paciente seja exposto a campo de radiação maior que o necessário preconizado pela ANVISA/RDC 330. **Resultados:** Estudou-se os resultados de cada máquina de raios-x avaliados, para isso criou-se um artefato simulador para mensurar e possibilitar a avaliação do diâmetro do campo de radiação dos raios x odontológico, onde foi possível medir o campo de radiação de cada aparelho para saber se estão condizentes com o recomendado pela RDC 330. Foi realizada uma análise de regressão linear para calcular o coeficiente de determinação (R2= 0, 0046) para demonstrar as diferenças nos diâmetros do campo de radiação. **Conclusão:** Este estudo sugere novas investigações para aprimoramento e validação deste artefato de simulação de raio - x.

Descritores: Raio-X Odontológico; Proteção Radiológica; Diâmetro do Campo de Radiação.

ABSTRACT

Objective: to test the quality control of intraoral dental X-ray devices in private practices in the Federal District, city of Gama. **Method:** the diameters of the radiation fields of these devices were measured, thus preventing the patient from being exposed to a radiation field larger than that recommended by ANVISA/RDC 330. **Results:** The results of each x-ray machine evaluated were studied, for this purpose a simulator artifact was created to measure and enable the evaluation of the diameter of the radiation field of dental x-rays, where it was possible to measure the radiation field of each device to know if they are consistent with that recommended by RDC/330. A linear regression analysis was performed to calculate the coefficient of determination (R2 = 0.0046) to demonstrate the differences in the diameters of the radiation field. **Conclusion:** This study suggests further investigations to improve and validate this x-ray simulation artifact.

Descriptores: dental X-Ray; Radiological Protection; Diameter of the Radiation Field.

RESUMEN

Objetivo: probar el control de calidad en dispositivos de rayos-X dentales intraorales en consultorios privados del Distrito Federal, ciudad de Gama. **Método:** se midieron los diámetros de los campos de radiación de estos dispositivos, evitando así que el paciente sea expuesto a un campo de radiación mayor al recomendado por ANVISA/RDC 330. **Resultados:** Los resultados de cada máquina de rayos-X evaluada, se creó un artefacto simulador para medir y permitir la evaluación del diámetro del campo de radiación de los rayos-X dentales, donde fue posible medir el campo de radiación de cada dispositivo para determinar si son consistentes con lo recomendado por la RDC 330. Se realizó un análisis de regresión lineal para calcular el coeficiente de determinación (R2= 0,0046) para demostrar las diferencias en los diámetros del campo de radiación. **Conclusión:** Este estudio sugiere más investigaciones con artefactos de simulación de rayos-X.

Descriptores: Radiografía Dental; Protección Radiológica; Diámetro del Campo de Radiación.

ORIGINAL

Introduction

Several researchers from Brazil and around the world have been publishing studies on radiological protection and due to these studies, radiological protection standards and standardization bodies were created, such as, with TECDOC-796, which deals with radiation doses in radiodiagnosis and methods for their reduction, another document cited by researchers was the international code of practice for dosimetry in radiodiagnosis in 2007. [1-2]

The International Commission on Radiological Protection, founded in 1928, is also an important reference for numerous countries for the development of radiological protection guidelines. [(3)]

In Brazil, the set of standards that govern the operation of radiodiagnostic services is specified in the Resolution - RDC Nº 330, of december 20, 2019. [(4)] This Resolution RDC 330 established the test parameters for executing the quality of radiodiagnostic beams and the appropriate criteria to be taken into consideration for assessing their conformity. (5)

Services that work with medical/dental radiodiagnosis, in order to comply with the specifications of ordinance 453/98, must periodically carry out quality control to analyze radiological parameters. The evaluation of these parameters directly helps in the control of radiodiagnostic equipment. [5]

The dose of radiation received by the patient is linked to the quality of a diagnostic x-ray beam; this dose must be reduced without compromising the obtainment of the radiographic image. Furthermore, the main objective of radioprotection determines that: “Occupational exposures and public exposures resulting from radiodiagnosis must be optimized to a value as low as practicable”. [2]

Simulator Artifact

The simulator object or phantom was created with the aim of using it in quality control tests of x-ray devices, training professionals and to evaluate the general quality of images for an accurate diagnosis. This testing tool has the function of reproducing characteristics of human tissues or organs in routine dosimetric procedures in radiodiagnosis. Human tissues or organs can also be introduced to the phantom. These simulators, in addition to helping with the quality control of x-ray equipment, also help with the training of professionals in the field. It can be said that phantoms are classified into dosimetric phantom, calibration phantom and anthropomorphic imaging phantom, all used in quality control tests.[6]

Radiation field

The radiation field of x-ray devices must be limited (collimated) to the region of diagnostic interest. In dental devices for intraoral x-rays there is a diaphragm that limits the diameter of the radiation field to which the patient will be exposed. This diaphragm is composed of a lead sheet with a central hole, attached to the tube head. In addition to being limited by the diaphragm, the field diameter is also limited by a collimator, which is generally cylindrical, approximately 20 cm long, composed of lead, coupled to the head. The diaphragm is the first to limit the radiation beam as it is located close to the exit of the x-ray tube; the collimator further limits the beam after it passes through the diaphragm. In intraoral images, the radiation field must have a maximum diameter of 6 cm at the exit end of the collimator. The collimator must have a minimum length of 18 cm for equipment with peak voltage less than or equal to 60 KVp; 20 cm for voltage between 60 and 70 KVp and 24 cm if the voltage is greater than 70 KVp. [2,4]

Radiographic film

Radiographic films follow a certain standard for their production which consists of a thin base layer of plastic coated with a radiation-sensitive emulsion. This emulsion is composed of grains of silver bromide (AgBr) suspended in gelatina.[6] This emulsion has the function of absorbing radiation during exposure to x-rays and producing a latent image and which after development becomes a radiographic image. As silver bromide grains (AgBr) are more sensitive to visible light than to radiation, radiographic films must be protected from glare. Coupled to plastic base there is a lead plate positioned behind the film. This plate has the function of to reduce the x-ray dose to the patient.

Objective

The objective of this work is to evaluate dental x-ray devices in eleven offices in the city of Gama, Federal District. To this end, a simulator object was created that allowed evaluating the diameter of the radiation field of dental devices and analyzing whether the measurements are in accordance with Resolution RDC 330, [7] which states that in intraoral images the diameter of the radiation field should not be greater than 6 cm.

Method

For the development of a dental radiation field simulator object, low-cost dental materials were used, as shown in (Figure 1), which served as support for the alignment of the radiological films and to measure the diameter of the radiation field of these films machines. To obtain the mold of the radiation field test object, alginate and self-polymerizing acrylic were used, in a 2:1 ratio of acrylic and liquid. In the tests, a simulator object was used and radiographic films were inserted into it. Subsequently, the films were exposed to X-rays and, after exposure, the films were removed for development in a darkroom.

Kodak brand developer and fixative were used to develop the films, and a lead apron was used to protect the professional.

Figure 1: Photo of the phantom produced.

To measure the diameter of the radiation field of each x-ray equipment analyzed in accordance with the limit recommended by Resolution RDC 330(7) of the Brazilian Ministry of Health, for this, the four films were aligned on the radiation field simulator object and exposed directly to the primary beam, we can see this in (Figure 2a), after development, the film sheets were aligned on the simulator object to measure the field diameter with a ruler, represented in (Figure 2b). To calculate the (coefficient of determination) R^2 and create the linear regression graph, Excel 2016 was used.

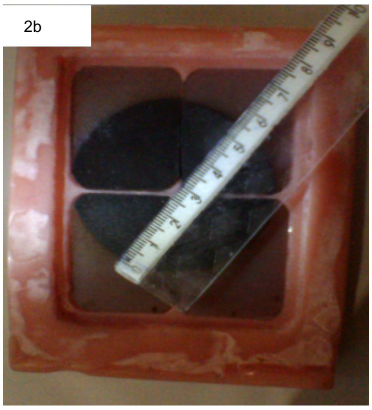

Figure 2a: Films aligned to evaluate the radiation field
Figure 2b: Measuring the diameter of the radiation field of the developed films

Results

The results were obtained through tests to evaluate the diameter of the radiation field using the simulator object for these measurements. After analyzing the quality control tests, we noticed that of the eleven devices researched, only four were above the recommended diameter. This means that the device is releasing a larger area of radiation than is necessary for diagnostic imaging, which results in an increase in the dose absorbed by the patient. Of these devices, one had a radiation field diameter of 5.5 cm and the other two of 5.6 cm, both results considered below the recommended level, but still within the limits allowed by ANVISA. The results of these tests are detailed in (Table 1).

Table 1-Test results for radiation field diameter measurements

Equipment	Radiation Field Diameter
A	5,6 cm
B	6,5 cm
C	7,0 cm
D	6,0 cm
E	7,0 cm
F	5,6 cm
G	6,5 cm
H	7,3 cm
I	6,0 cm
J	6,5 cm
L	5,5 cm

The largest diameter of the radiation field was 7.3 cm, followed by 7.0 cm and 6.5 cm, therefore larger than that recommended by Resolution RDC 330 (Figure 3). To develop the films, we used a red, portable darkroom. Of the eleven clinics visited, we can see that four of them used dental x-ray devices with an analog trigger, and these are clinics 4, 5, 6, and 9 respectively.

When developing the films, we used Kodak solutions and the film development time for most clinics was 1m to 2m, with practice 4 being the one that took the longest to develop the films, taking 3m to develop them. But this did not damage any of the developed films.

To present the discrepancy in the emission diameters of the X-ray devices of the analyzed dental clinics, a graph was made (Figure 3) where the linear regression was presented with the R^2 value (coefficient of determination) with the value of R^2 = 0, 0046.

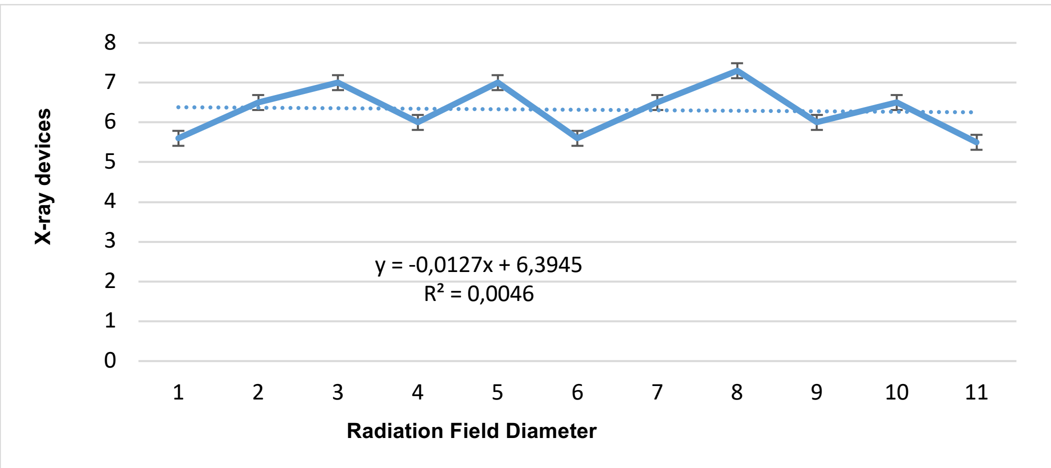

Figure 03. Test results represented in a scatter plot for measurements of the diameter of the radiation field

The data presented in the graph above represents the dental clinics on the "x" axis by numbers. Thus, the number 1 means clinic A, 2 means B and so on, until the number 11.

Discussion

Based on quality control tests carried out in dental clinics in the City of Gama-DF, it was possible to evaluate several dental x-ray devices by checking the diameter of the radiation field in accordance with Resolution RDC 330 [7] and in view of this it was possible to observe that in 45.4% of the devices, the diameter of the exposure field was not in accordance with recommendations. The device in office 11 had a radiation field of 5.5, therefore lower than recommended, but within the standard.

The simulator object was effective in the test, helping to position the radiographic films and, thus, presenting a safe method for carrying out radiation field measurements in dental X-rays. The phantom can be made with good quality raw materials and has a low financial cost, and can be a good alternative for quality control of this equipment.

Conclusion

With these studies, we began a Quality Control Program following the standards of the National Health Surveillance Agency (ANVISA), which is a very important step towards improving the provision of radiological services for the population of the city of Gama-DF. Thus, we will expand our field of study in imaging diagnostics, also guiding professionals in the area and providing more information on ANVISA standards for equipment quality control, image quality control and radiological protection.

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