Marina Caldas Poletto

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Dissertação de Mestrado submetida à Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação em Ciências da Saúde da Universidade de Caxias do Sul, como parte dos requisitos necessários para a obtenção do título de Mestre em Ciências da Saúde.

Caxias do Sul

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Caxias do Sul
2023

Dados Internacionais de Catalogação na Publicação (CIP)
Universidade de Caxias do Sul
Sistema de Bibliotecas UCS - Processamento Técnico

P765d Poletto, Marina Caldas
Desenvolvimento de colimador retangular para uso com aparelhos de raios X em exames odontológicos [recurso eletrônico] / Marina Caldas Poletto. – 2023.
Dados eletrônicos.

Dissertação (Mestrado) - Universidade de Caxias do Sul, Programa de Pós-Graduação em Ciências da Saúde, 2023.
Orientação: Cláudio Antônio Perottoni.
Coorientação: Thiago de Oliveira Gamba.
Modo de acesso: World Wide Web
Disponível em: https://repositorio.ucs.br

1. Dentes - Radiografia. 2. Proteção radiológica. 3. Radiação. 4. Raios X - Equipamento e acessórios. I. Perottoni, Cláudio Antônio, orient. II. Gamba, Thiago de Oliveira, coorient. III. Título.

CDU 2. ed.: 616.314-073.7

Catalogação na fonte elaborada pela(o) bibliotecária(o)
Márcia Servi Gonçalves - CRB 10/1500

UNIVERSIDADE DE CAXIAS DO SUL

PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA SAÚDE

COORDENADOR DO PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA SAÚDE

PROF. DR. JOSÉ MAURO MADI

Marina Caldas Poletto

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Orientador:

Prof.Dr. Cláudio Antônio Perottoni
Universidade de Caxias do Sul

Co-Orientador

Prof.Dr. Thiago de Oliveira Gamba
Universidade de Caxias do Sul

Banca examinadora:

Prof.Dr. João Lopes Bondan
Universidade de Caxias do Sul

Prof.Dra. Suzana Uggeri Coradini
Universidade de Caxias do Sul

Prof.Dr. Luciano Augusto Cano Martins
Medical University of Lublin (Poland)

Dedicatória

Dedico esse trabalho primeiramente à minha família que sempre esteve ao meu lado em todos os momentos, dedico também aos meus mestres que me inspiraram e incentivaram a seguir adiante.

Agradecimentos

Aos meus mentores Professor Cláudio Antônio Perottoni e Professor Thiago de Oliveira Gamba bem como ao colega Eduardo Thomazi e professora Janete Zorzi, que me acompanharam em toda a trajetória, sempre se dispondo prontamente.

Sumário

1. INTRODUÇÃO

As radiografias intrabucais na prática odontológica são fundamentais como métodos complementares de diagnóstico (1), em consonância com a importância da sua utilização e considerando os riscos inerentes ao uso das radiações ionizantes, as indicações para realização de exames radiográficos devem ser avaliadas para evitar que o paciente seja exposto à radiação de forma injustificada. Tal conduta segue um dos princípios básicos da proteção radiológica, ao qual garante ao paciente o mínimo de dose de radiação e apenas quando tal é cientificamente comprovada como necessária, garantido, no Brasil, pela resolução RDC Nº 611, de 9 de março de 2022 (2).

A Comissão Internacional em Proteção Radiológica e a Agência Internacional de Energia Atômica recomendam fortemente a redução da exposição à radiação e a utilização de estratégias para redução do risco (3,4). Para seguir os preceitos de proteção radiológica, a justificativa do exame radiográfico deve mensurar os benefícios e os riscos que a exposição causará ao paciente. Considerando também a otimização do exame, evitando a necessidade de novas exposições. Confirmando o benefício clínico, é necessário criar barreiras para minimizar as áreas expostas à radiação ionizante (1).

As precauções radioprotetoras são responsabilidade do cirurgião-dentista, sendo necessária a avaliação da indicação clínica levando em consideração o exame adequado para cada situação clínica, uma boa técnica radiográfica, redução da área exposta aos raios X, por meio dos coletes de chumbo e colimadores, bem como utilizando uma dose de radiação mais baixa para uma imagem diagnosticamente aceitável orientado pela indicação e específico ao paciente, seguindo o princípio *ALADAIP (As Low As Diagnostically Acceptable being Indication-oriented and Patient-specific)* (5,6,7). Métodos para barrar a radiação devem ser seguidos de forma criteriosa pelos profissionais da saúde, uma vez que a radiação causa inúmeros malefícios à saúde geral tanto ao operador quanto ao paciente (8).

Dentre todos os instrumentos que o profissional pode utilizar como barreira radioprotetora, o colimador é extremamente importante para para reduzir a quantidade de radiação desnecessária dispersa ao paciente. Os aparelhos odontológicos para realização de radiografias intraorais contam com um colimador integrado com formato circular, que restringe parte da radiação ionizante, no entanto, devido ao seu formato, uma grande área é exposta a radiação sem necessidade (9). Já a colimação retangular se mostra com muito mais eficiência ao barrar a radiação desnecessária (10).

Para oferecer uma maior segurança e menor área irradiada, o colimador retangular apresenta uma função satisfatória e indispensável para o correto manejo durante o exame radiográfico, contribuindo para preservar o paciente de doses de radiações desnecessárias devido a diminuição da área exposta (11).

A utilização de colimação retangular é altamente recomendada devido a redução de dose de radiação clinicamente relevante para os pacientes, oferecendo uma maior segurança para radiação ionizante quando comparado com a colimação circular (12). Em diversos países a utilização de colimadores retangulares é obrigatória, visando preservar o paciente de radiação, com exposição fora da área de interesse (13).

Considerando a demanda de aumentar a proteção do paciente com uma maior restrição da área irradiada obtida por meio de um colimador retangular e considerando que as lâminas de chumbo são facilmente encontrado nos filmes intrabucais de processamento radiográfico manual, sendo na maioria das vezes descartado, e sendo um material de alta densidade capaz de absorver a radiação (1), propõe-se o desenvolvimento de um artefato radioprotetor para reduzir a área irradiada reciclando as lâminas de chumbo para a confecção de um colimador retangular que poderá ser acoplado no cilindro localizador dos equipamentos de radiografia utilizados em clínicas odontológicas.

2. REFERÊNCIAS

1. White SC, Mallya SM. Update on the biological effects of ionizing radiation, relative dose factors and radiation hygiene. *Aust Dent J* 2012; **57** Suppl 1:2-8. https://doi.org/10.1111/j.1834-7819.2011.01665.x
2. Brasil. Ministério da Saúde. RESOLUÇÃO - RDC Nº 611, DE 9 DE MARÇO DE 2022. Brasília, DF: Diário Oficial da União, 2022. https://www.in.gov.br/web/dou/-/resolucao-rdc-n-611-de-9-de-marco-de-2022-386107075
3. International Commission on Radiological Protection (ICRP). Recomendations of the ICRP. ICRP Publication 103. Ann ICRP. 2008;37:2–4.
4. International Atomic Energy Agency. IAEA safety standards for protecting people and the environment. Radiation protection and safety of radiation Sources: international basic safety standards. General safety requirements part 3, 2014. Vienna, Austria: IAE.
5. Van Acker JWG, Pauwels NS, Cauwels RGEC, Rajasekharan S. Outcomes of different radioprotective precautions in children undergoing dental radiography: a systematic review. *Eur Arch Paediatr Dent* 2020; **21**(4):463-508. https://doi.org/10.1007/s40368-020-00544-8
6. Lorenzoni DC, Bolognese AM, Garib DG, Guedes FR, Sant'anna EF. Cone-beam computed tomography and radiographs in dentistry: aspects related to radiation dose. *Int J Dent* 2012; **2012**:813768. https://doi.org/10.1155/2012/813768
7. Kühnisch J, Anttonen V, Duggal MS, Spyridonos ML, Rajasekharan S, Sobczak M, Stratigaki E, Van Acker JWG, Aps JKM, Horner K, Tsiklakis K. Best clinical practice guidance for prescribing dental radiographs in children and adolescents: an EAPD policy document. Eur Arch Paediatr Dent. 2020 Aug;21(4):375-386. doi: 10.1007/s40368-019-00493-x.
8. Benn DK, Vig PS. Estimation of x-ray radiation related cancers in US dental offices: Is it worth the risk? *Oral Surg Oral Med Oral Pathol Oral Radiol* 2021; **132**(5):597-608. https://doi.org/10.1016/j.oooo.2021.01.027
9. 6. Johnson KB, Ludlow JB. Intraoral radiographs: A comparison of dose and risk reduction with collimation and thyroid shielding. *J Am Dent Assoc* 2020; **151**(10):726-734. https://doi.org/10.1016/j.adaj.2020.06.019
10. Hoogeveen RC, de Randamie TI, Soemodihardjo GM, Berkhout W. Ambient dose during intraoral radiography with current techniques: Part 1 conversion factor for scattered radiation using a rectangular collimator. *Dentomaxillofac Radiol* 2018; **47**(7):20180108. https://doi.org/10.1259/dmfr.20180108
11. Campbell RE, Wilson S, Zhang Y, Scarfe WC. A survey on radiation exposure reduction methods including rectangular collimation for intraoral radiography by pediatric dentists in the United States. *J Am Dent Assoc* 2020 **151**(4):287-296. https://doi.org/10.1016/j.adaj.2020.01.014
12. Shetty A, Almeida FT, Ganatra S, Senior A, Pacheco-Pereira C. Evidence on radiation dose reduction using rectangular collimation: a systematic review. *Int Dent J* 2019; **69**(2):84-97. https://doi.org/10.1111/idj.12411
13. Magill D, Ngo NJH, Felice MA, Mupparapu M. Kerma area product (KAP) and scatter measurements for intraoral X-ray machines using three different types of round collimation compared with rectangular beam limiter. *Dentomaxillofac Radiol* 2019; **48**(2):20180183. https://doi.org/10.1259/dmfr.20180183

3. ARTIGO

DEVELOPMENT OF AN OPEN PROJECT RECTANGULAR COLLIMATOR FOR USE WITH INTRAORAL DENTAL X-RAY UNIT

ABSTRACT

Objectives: To develop an open project rectangular collimator to be attached to an intraoral dental X-ray unit, using recycled lead sheets as a radiation-absorbing element.
Methods: The collimator was dimensioned for use with the Procion® brand model Ion 70X-Mobile Column equipment, with 70 kV-3mA Class 1 type B common head and the autoclavable radiographic film holder devices Indusbello and Kerr™ brand number 900170. After defining the collimator dimensions, a STL (Structure Triangular Language) file for 3D printing was generated and a calculation was performed to define the number of recycled lead sheets used to absorb radiation. The reduction in radiation dose in patients undergoing analysis was estimated from geometrical considerations and simulations carried out with Spektr 3.0 software.
Results: The rectangular collimator here proposed reduced radiation dose in patients in 65% percent when using four layers of recycled lead sheets (saturating at 70% reduction in radiation dose in the limit of eight or more lead sheets). The rectangular collimator does not negatively impact the quality of the radiologic image.
Conclusions: The rectangular collimator here designed is available as an open project for 3D printing and may be built using materials easily accessible to dentists, thus facilitating its use in clinical practice and benefiting patients by reducing exposure to ionising radiation.

Keywords: radiation protection, radiology, radiation dose.

Introduction

Intraoral radiographs in dental practice are essential as complementary diagnostic methods[1], due to the importance of their use and considering the risks inherent in the use of ionising radiation, the indications for performing radiographic examinations must be evaluated to prevent the patient from being exposed to radiation unjustifiably. Such conduct follows one of the basic principles of radiological protection, which guarantees the patient a minimum dose of radiation and only when scientifically proven to be necessary. Both the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA) have strong recommendations for risk reduction strategies[2-4]. In order to follow the precepts of radiological protection, the justification for the radiographic examination must consider the benefits and risks that the exposure will entail for the patient. Then, after confirming the clinical benefit, it is anyway salutary to create barriers to minimise the dose of ionising radiation incident on the patient[1] .

Radioprotective precautions are the responsibility of the dentist, and it is necessary to evaluate the clinical indication, reduce the area exposed to X-rays (for instance, using lead vests and collimators), and reduce the dose of ionising radiation to an acceptable minimum without compromising image quality, following the ALARA (As Low As Reasonably Achievable) principle[5,6]. In addition, methods to block radiation must be carefully followed by health professionals since radiation causes numerous harm to general health, both to the operator and the patient[7].

Among all the instruments that the professional can use as a radioprotective barrier, the X-ray tube collimator is extremely important to focus and restrict the area to be irradiated. Standard X-ray devices for performing intraoral radiographs have an integrated collimator with a circular shape. However, due to its shape and angular aperture, a large area is exposed to radiation unnecessarily[8]. On the other hand, a rectangular collimator at the exit point of the X-ray tube can be made in such a way as to block unnecessary radiation[9]. In fact, to offer greater safety and a smaller irradiated area, the addition of a rectangular collimator may help to preserve the patient from unnecessary radiation doses due to the reduction of the exposed area[10].

The use of rectangular collimation is highly recommended due to the clinically relevant radiation dose reduction for patients, offering greater protection when compared with circular collimation[11]. In several countries, the use of rectangular collimators is mandatory, aiming to preserve the patient from radiation, with exposure outside the area of interest[12].

Considering the demand to increase patient protection with as great as possible restriction of the irradiated area (as can be obtained using a rectangular collimator which precisely fits the are of the intraoral radiologic film to be exposed) and considering that lead sheets are a common and easily found part of manual processing intraoral films, most of the time being discarded after use, it is proposed the construction of a radioprotective device to reduce the irradiated area by using recycling lead sheets as the absorbing element of a rectangular collimator to be attached to the guiding cylinder at the end of the X-ray tube of the radiography equipment used in the dental clinic.

Materials and methods

The particular collimator described here was dimensioned to be used with the Procion® intraoral dental X-ray device, model Ion 70X-Mobile Column with 70kV-3mA Class 1 type B common head, and with the autoclavable radiographic film holder devices from Indusbello and Kerr™ number 900170. To determine the size of the rectangular collimator aperture, the distance from the radiation source to the film placed in the plate holder device was estimated, and all calculations were made considering geometrical optics principles.

The three-dimensional (3D) prototype was designed using computer-aided design (CAD) software, and the file was generated in STL format for printing. The body of the rectangular collimator was printed using a model i3 Mega (Anycubic) 3D printer and a Fused Filament Fabrication/Fused Deposition Modeling (FFF/FDM) printing system. The structural part of the collimator was printed with polylactic acid (PLA) polymer using filaments of 1.75 mm diameter. The radiation absorbing material was recycled lead sheets 0.045mm thick from Carestream Dental IP-21 F-Speed radiographic film (Size 2, Adult or Standard).

The composition of the absorbing metallic sheets (here referred to as lead sheets) was determined by energy-dispersive X-ray fluorescence spectroscopy (EDX7000, Shimadzu). Simulations were performed using the Spektr 3.0 software to determine the number of layers of lead sheets and their effect on radiation dose in a patient. Simulations were performed considering the a X-ray tube of 70 kVp, with a aluminium filter. The radiation dose at a fixed distance from the X-ray source was simulated considering absorption from zero to ten 0.45 mm superimposed lead sheets[13]. The rectangular aperture of the collimator was considered in estimating the radiation dose reduction.

Test exposures of 0.56 seconds duration were performed with and without the collimator by exposing a radiographic film Carestream Dental Intraoral Occlusal IO – 41, 57mm x 76mm, held at a fixed distance from the X-ray source, to assess the functionality of the rectangular collimator to block unnecessary radiation. A MOM brand synthetic jaw was used to evaluate the efficiency of the rectangular collimator in terms of its impact on image quality, comparing images obtained in the presence and absence of the collimator.

The radiographic film processing was performed using the manual technique in a darkroom, following the manufacturer's guidelines. The temperature of the liquid was measured with a digital thermometer and indicated 24.8°C, for which the correct time for processing in the developer was 2 minutes and 54 seconds. Film development is followed by washing for 30 seconds in water to remove excess developer, fixing for 10 minutes, and finishing with a 10-minute wash in water and drying of the film. This process was repeated following exactly the same procedure for every radiographic film test used in this work.

Results

The size of the rectangular collimator opening was defined based on geometric parameters, including the distance between the radiation source and the radiographic film fitted to the plate holder device (Figure 1).

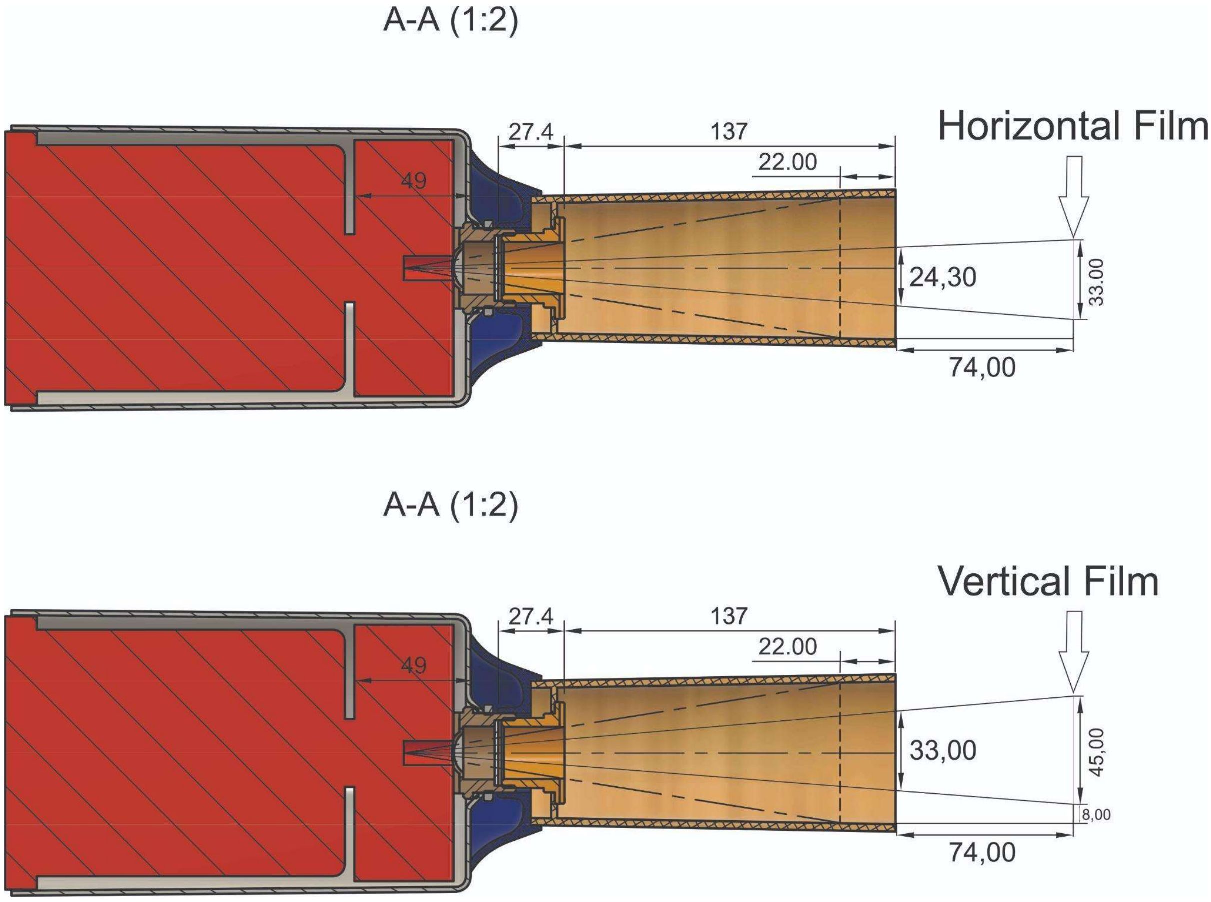


Figure 1 Schematic representation of the X-ray tube (red) and guiding cylinder (brown), along with some measurements (in mm). At the right, the position of the intraoral radiographic film is represented, with the linear dimension of the film to be exposed to radiation along two orthogonal directions (horizontal and vertical). The corresponding apertures of the collimator rectangular window are 24.3 mm and 33.0 mm, respectively.

The 3D design of the collimator was carried out using computer-aided design software, and later two parts that fit together were 3D printed (see Figure 2). Figure 2 also shows how the lead sheets are arranged in the collimator, the opened window and finally the attached intraoral film holder.

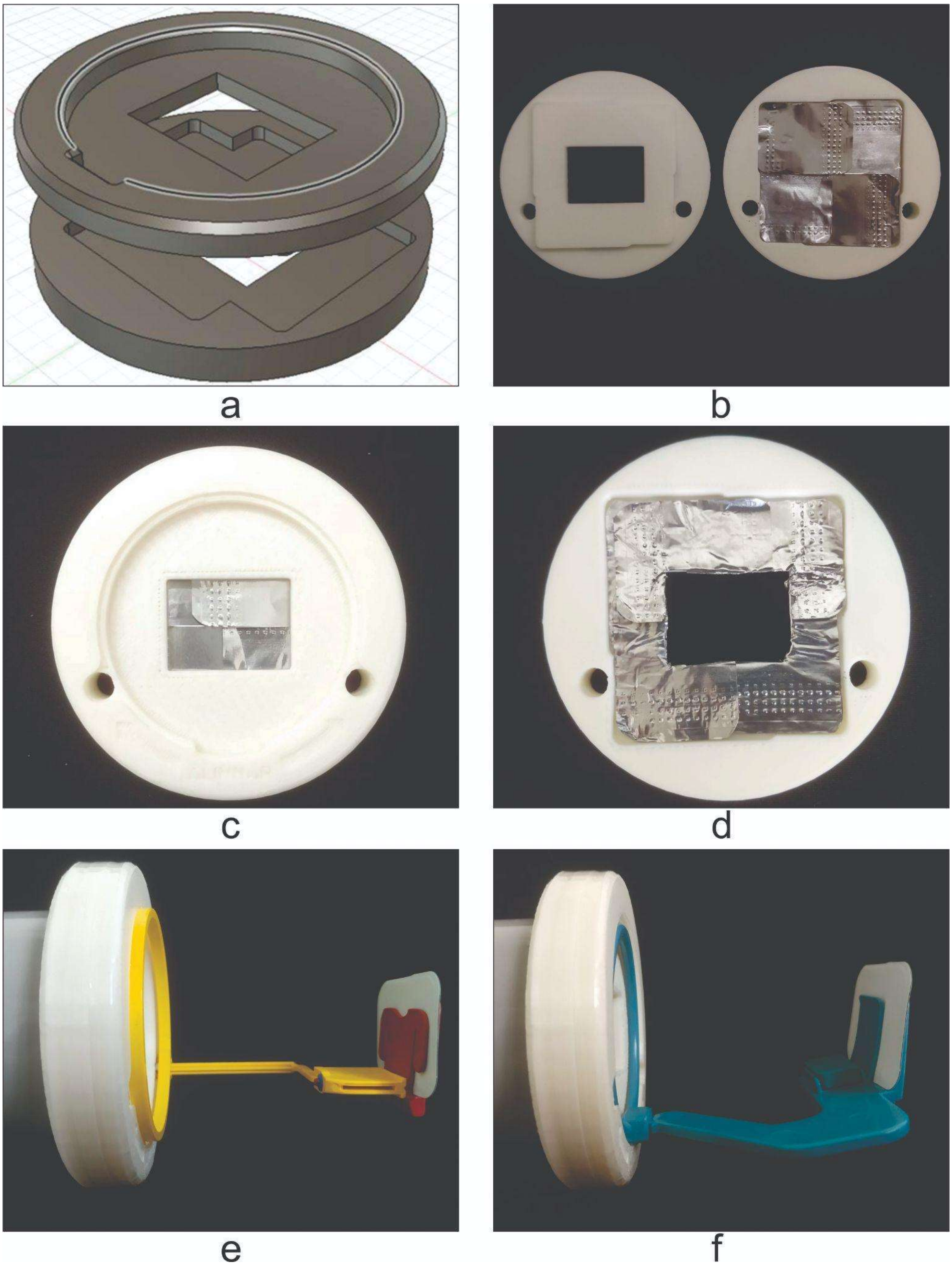


Figure 2 (a) Prototype designed for 3D printing. Prototype printed with lead sheets before (b) and after (c) placing the lid. (d) Collimator with superimposed lead sheets and opened rectangular window. (e) Collimator attached to the X-ray tube guide cylinder and Kerr™ plate holder device. (f) Collimator coupled to the X-ray tube guide cylinder and the Indusbello™ plate holder device.

The metal sheets used in the construction of the rectangular X-ray collimator are composed of lead (>95%), with a small content of tin and antimony, as revealed by the X-ray fluorescence analysis. The reduction in radiation dose was calculated according to the number of superimposed layers of lead sheets, indicating a 65% reduction in radiation dose when using four layers and up to 70% reduction when using eight or more layers as absorbing material (Figure 3).

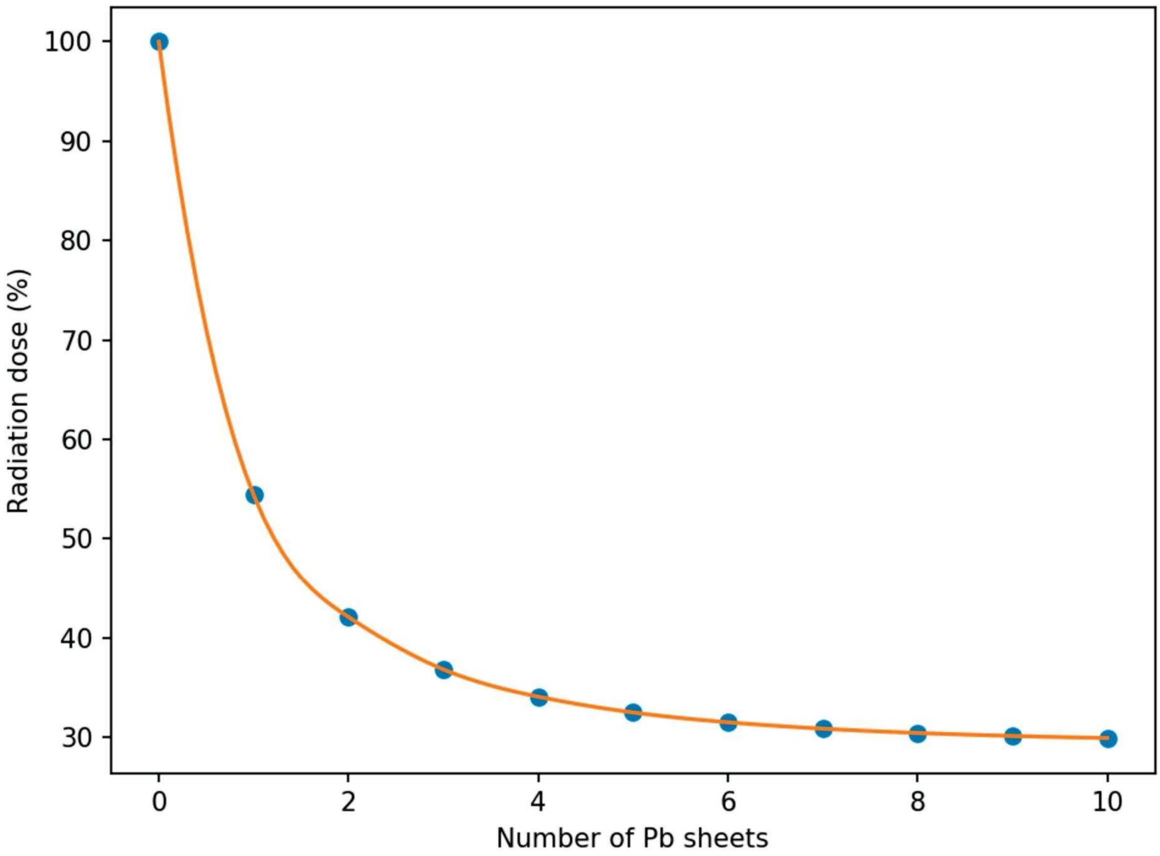


Figure 3 Radiation dose at a fixed distance from the X-ray source *versus* the number of layers of the absorbing material (lead sheets). The radiation dose is given relative to the value calculated in the absence of the rectangular collimator.

After testing and manual processing of the intraoral radiographic films, a visual analysis of the radiation exposure area was performed, which is revealed by the high-density radiolucent area. In the exposures where the rectangular collimator was not used, it is observed that the radiation completely affected a circular area much greater than the area of clinical interes (Figure 4a). By using the rectangular collimator, the exposed are is reduced to exactly fit the film dimensions in the intraoral plate holder (Figure 4b).

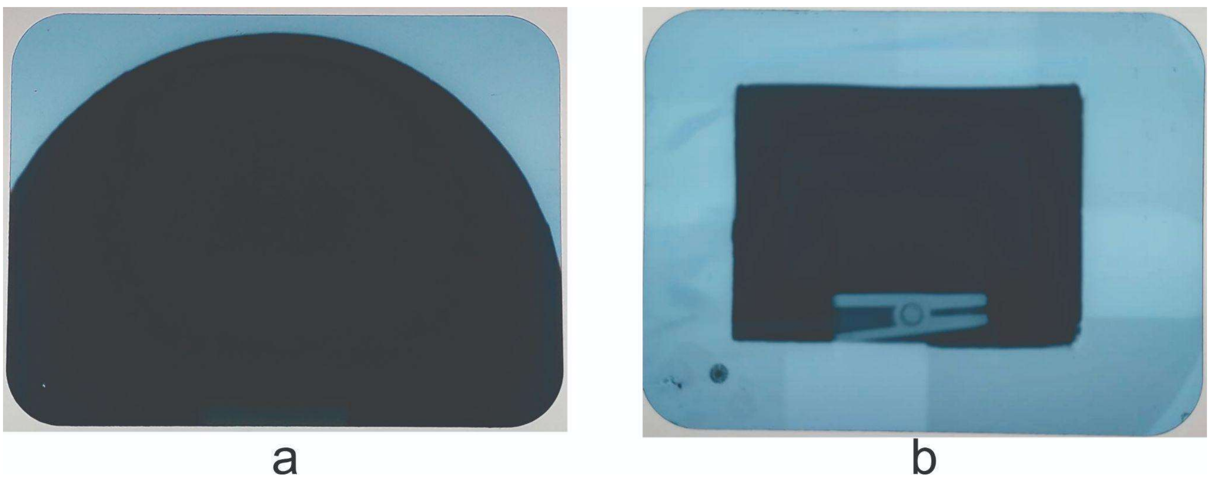
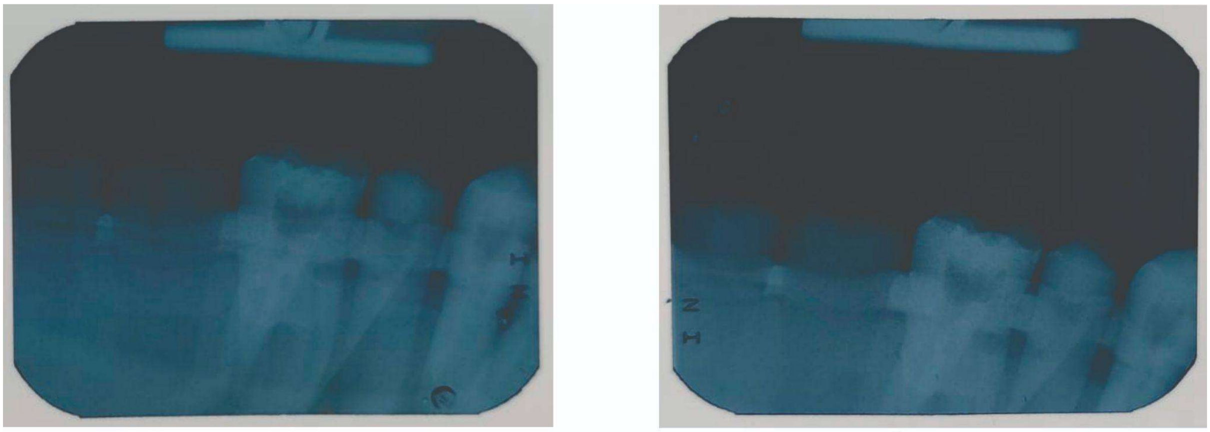


Figure 4 (a) Occlusal film exposed to radiation without collimation. (b) Occlusal film exposed to radiation with rectangular collimation. The dimensions of the exposed are in (b) correspond to those of the intraoral film for which the collimator was designed. Observe

how radiation is reduced outside the area of clinical interest.

Tests performed with and without the rectangular collimator show no reduction of image quality or loss of important structures in the images when the collimator is used (Figure 5).



a b

Figure 5: (a) Exposure of a periapical film on a MOM brand synthetic mandible without the collimator. (b) Exposure of a periapical film on a MOM brand synthetic mandible with the collimator.

Discussion

During the elaboration of the design of the collimator prototype, the correct positioning of the radiographic film in the cone of incidence of ionising radiation was taken into account. Accordingly, the dimensions of the collimator rectangular window is such that radiation is restricted to incidence on the radiologic film in the plate holder device of choice as well as to the guiding cylinder of the X-ray tube.

Positioning failure when using rectangular collimation is one of the concerns of dentists, according to a study by Senior et al.[15] Other study suggests that the use of an intraoral radiographic film holder device combined with a circular collimator decreases the frequency of radiographic errors and there was an increase in incidence errors when using rectangular collimation without a plate holder device[14]. The design of the rectangular collimator here described was made so that the plate holder device is fitted to the guiding cylinder, thus preventing incorrect positioning. In this sense, visually evaluating the results of radiographic exposures with and without the rectangular collimator shows an important ionising radiation reduction outside the are of a clinical interest when using the rectangular collimator. Simulations indicate a reduction of exposure to ionising radiation from 65% to 70% using four to eight layers of lead sheets as radiation barrier, respectively. This result is in good agreement with Shetty et al systematic review, which reports a significant reduction in radiation dose, from 40% to 92%, when using a rectangular collimator[11].

Conclusions

The 3D-printed rectangular collimator here proposed and built using recycled lead sheets promoted a 65% reduction in radiation exposure using four sheets of lead foil (up to 70% reduction when eight sheets of lead were used), without impacting negatively on the overall quality of the radiologic image.

The STL files for 3D printing of the rectangular collimator were made freely available at https://www.thingiverse.com/thing:5841403. These files can be easily edited to conform to particular models of X-ray tubes and plate holders in case these are different from those used in this work.

The rectangular collimator here designed and made available as an open project for 3D printing may be built using materials easily accessible to dentists, thus facilitating its use in clinical practice and benefiting patients by reducing exposure to ionising radiation.

Acknowledgments

The support from the Brazilian Government Agency Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) - grant 305528/2018-1 is gratefully acknowledged. This study was also financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001. Thanks are due to Luiza F. Lima for X-ray fluorescence analysis of the lead sheets, and the Manufacturing Laboratory of Federal Institute of Rio Grande do Sul - Caxias do Sul, where the collimator parts were 3D printed.

REFERENCES

1. White SC, Mallya SM. Update on the biological effects of ionizing radiation, relative dose factors and radiation hygiene. *Aust Dent J* 2012; **57** Suppl 1:2-8. https://doi.org/10.1111/j.1834-7819.2011.01665.x
2. Brasil. Ministério da Saúde. RESOLUÇÃO - RDC Nº 611, DE 9 DE MARÇO DE 2022. Brasília, DF: Diário Oficial da União, 2022. https://www.in.gov.br/web/dou/-/resolucao-rdc-n-611-de-9-de-marco-de-2022-386107075
3. International Commission on Radiological Protection (ICRP). Recomendations of the ICRP. ICRP Publication 103. Ann ICRP. 2008;37:2–4.
4. International Atomic Energy Agency. IAEA safety standards for protecting people and the environment. Radiation protection and safety of radiation Sources: international basic safety standards. General safety requirements part 3, 2014. Vienna, Austria: IAE.
5. Van Acker JWG, Pauwels NS, Cauwels RGEC, Rajasekharan S. Outcomes of different radioprotective precautions in children undergoing dental radiography: a systematic review. *Eur Arch Paediatr Dent* 2020; **21**(4):463-508. https://doi.org/10.1007/s40368-020-00544-8
6. Lorenzoni DC, Bolognese AM, Garib DG, Guedes FR, Sant'anna EF. Cone-beam computed tomography and radiographs in dentistry: aspects related to radiation dose. *Int J Dent* 2012; **2012**:813768. https://doi.org/10.1155/2012/813768
7. Benn DK, Vig PS. Estimation of x-ray radiation related cancers in US dental offices: Is it worth the risk? *Oral Surg Oral Med Oral Pathol Oral Radiol* 2021; **132**(5):597-608. https://doi.org/10.1016/j.oooo.2021.01.027
8. Johnson KB, Ludlow JB. Intraoral radiographs: A comparison of dose and risk reduction with collimation and thyroid shielding. *J Am Dent Assoc* 2020; **151**(10):726-734. https://doi.org/10.1016/j.adaj.2020.06.019
9. Hoogeveen RC, de Randamie TI, Soemodihardjo GM, Berkhout W. Ambient dose during intraoral radiography with current techniques: Part 1 conversion factor for scattered radiation using a rectangular collimator. *Dentomaxillofac Radiol* 2018; **47**(7):20180108. https://doi.org/10.1259/dmfr.20180108
10. Campbell RE, Wilson S, Zhang Y, Scarfe WC. A survey on radiation exposure reduction methods including rectangular collimation for intraoral radiography by pediatric dentists in the United States. *J Am Dent Assoc* 2020 **151**(4):287-296. https://doi.org/10.1016/j.adaj.2020.01.014
11. Shetty A, Almeida FT, Ganatra S, Senior A, Pacheco-Pereira C. Evidence on radiation dose reduction using rectangular collimation: a systematic review. *Int Dent J* 2019; **69**(2):84-97. https://doi.org/10.1111/idj.12411
12. Magill D, Ngo NJH, Felice MA, Mupparapu M. Kerma area product (KAP) and scatter measurements for intraoral X-ray machines using three different types of round collimation compared with rectangular beam limiter. *Dentomaxillofac Radiol* 2019; **48**(2):20180183. https://doi.org/10.1259/dmfr.20180183
13. Punnoose J, Xu J, Sisniega A, Zbijewski W, Siewerdsen JH. Technical Note: spektr 3.0-A computational tool for x-ray spectrum modelling and analysis. *Med Phys [Internet]* 2016; **43**(8):4711. https://doi.org/10.1118/1.4955438
14. Parrott LA, Ng SY. A comparison between bitewing radiographs taken with rectangular and circular collimators in UK military dental practices: a retrospective study. *Dentomaxillofac Radiol* 2011; **40**(2):102-9. https://doi.org/10.1259/dmfr/86968802
15. Senior A, Tolentino Almeida F, Geha H, Pachêco-Pereira C. Intraoral Imaging in Dental Private Practice - A Rectangular Collimator Study. *J Can Dent Assoc.* 2020; **86**:k16. https://jcda.ca/sites/default/files/k16_0.pdf

4. CONSIDERAÇÕES FINAIS E PERSPECTIVAS

A utilização da colimação retangular é comprovadamente mais segura para pacientes e operadores no que se refere à proteção contra a radiação ionizante. A disponibilização do arquivo do colimador retangular, passível de edição e impressão 3D, tornará esse recurso para proteção à radiação mais acessível aos cirurgiões-dentistas.

Vislumbra-se, no próximo momento, a criação de dispositivos que possibilitem a identificação da área irradiada por meio de iluminação específica partindo do colimador, de forma que seja possível a conferência e a correção de posicionamento prévio à exposição e, desta forma, colaborar ainda mais com a proteção à radiação, visto que poderá evitar exposições extras desnecessárias.

Tendo em vista os benefícios da colimação retangular, propõe-se a elaboração de colimadores adaptados a outros tamanhos de filmes radiográficos intrabucais, como por exemplo os pediátricos, de forma a se adequar às possibilidades de exposições e aumentar a proteção à radiação na maioria dos casos possíveis.