Jurnal Info Kesehatan
Vol. 19, No. 1, June 2021, pp. 28-37
P-ISSN 0216-504X, E-ISSN 2620-536X
DOI:*10.31965/infokes.Vol19Iss1.505*
Journal homepage: *http://jurnal.poltekeskupang.ac.id/index.php/infokes*

RESEARCH Open Access

Innovation of Dental X-Ray Holder Using Silicone Rubber Coating in Posterior Dental Periapical Intraoral Examination

Marichatul Jannah[1a*], Saifudin[1b] , Wingghayarie Patra Gandhi[2c]

[1] Department of Radiodiagnostic Engineering and Radiotherapy, Poltekkes Kemenkes Semarang, Semarang, Central Java, Indonesia.
[2] Oral and Dental Hospital, Muhammadiyah University of Semarang, Semarang, Indonesia.

[a] Email address: marichatuljannah@poltekkes-smg.ac.id
[b] Email address: sae.udine@gmail.com
[c] Email address: wingghayariepg@gmail.com

Received: 11 January 2021 Revised: 20 April 2021 Accepted: 31 May 2021

Abstract
The major drawback of the parallel periapical examination technique is that the holder used can damage the oral tissues and cause discomfort to the patient. The objective of this study is to determine the work efficiency and radiographic quality of the innovative dental x-ray holder which has been made by adding synthetic rubber or silicone to the part of the holder that is in direct contact with the patient. This research is an experimental with a post-test only design. The analysis was performed based on filling out the questionnaire on a Likert scale ranging from 1 to 4. With the criteria 1. Disagree, 2. Sometimes, 3. Agree and 4. Strongly Agree. The test was administered by comparing the holder made with the commonly used Aphrodite holder as a control group. There were 16 repetitions of exposure to the cadaveric skull in obtaining research data for each treatment group. The results of statistical work efficiency testing on the control group resulted in a value of B = 0.125 with a significance of 0.071 and an effect of 10.5%. Meanwhile, for testing the quality of radiographic image, the value of B = 0.125 with a significance of 0.014 and an effect of 18.5% was obtained. The innovative dental x-ray holder using a silicone rubber layer is efficient and the resulting radiographic image quality is good when used in the intraoral examination.

Keywords: Periapical, Parallel Technique, Holder, Silicon.

Corresponding Author:

Marichatul Jannah
Department of Radiodiagnostic Engineering and Radiotherapy, Poltekkes Kemenkes Semarang, Semarang, Central Java, Indonesia.
Email: marichatuljannah@poltekkes-smg.ac.id

1. INTRODUCTION

Premolar teeth are one of the teeth of the posterior tooth group located in the posterior region of the oral cavity (Arx & Lozanoff, 2016). Many conditions or diseases cause pain in these premolar teeth. As a result, in certain conditions, the tooth that is experiencing the problem must be pulled out. The first premolar teeth are the teeth most frequently performed (Dardengo, et. al., 2016). To support the extraction procedure, generally, a dental radiographic examination is required.

The dental radiographic examination is a medical procedure performed to diagnose trauma, inflammation, abscess, fracture, or tooth injury in the area of the tooth being examined using x-rays (Whitley, et. al., 2015). In dental radiographic examination, there are two film placement techniques which are generally used, that is placing the film outside the oral cavity known as extra-oral radiographic examination and placing the film in the oral cavity known as intraoral radiographic examination (Iannucci & Howerton, 2016).

Intraoral radiographic examination is an examination used for examining teeth and adjacent structures in the oral cavity. The intraoral radiographic examination is the basic examination of dental radiographs. Intraoral radiographs require a receptor device such as a film, IP (Imaging Plate) or detector. The receptors used in intraoral radiographs are placed in the oral cavity to obtain images of the teeth and their supporting tissue structures. In intraoral radiographic examinations, in general, dental examinations are performed separately between parts including the incisor, caninuas, premoral or molars (Whaites & Drage, 2013). There are several types of intraoral radiographs such as occlusal, bitewing, and periapical.

Periapical examination represents an intraoral radiographic technique designed to present the individual teeth and tissue around the apex. Each image can typically show two to four teeth and provide detailed information about the teeth and surrounding alveolar bone (Whaites & Drage, 2013). There are two methods which can be used to obtain periapical images, that are the bisecting technique and the parallel technique (Iannucci & Howerton, 2016).

Parallel technique is used to obtain dimensionally accurate periapical images based on the concept of parallelism. The concept of parallelism used in this parallel technique is the position of the receptor and the teeth, arranged parallel to each other in the direction of the x-ray perpendicular to the receptor used. Furthermore, the parallel technique also requires a tool to support the receptors in the oral cavity which is usually called a holder (Reynolds, 2016).

The advantage of using the parallel technique is it is able to produce radiographic images without dimensional distortion. The parallel technique produces images that have dimensional accuracy which is very representative of the actual condition of the teeth and shows maximum detail and information. The parallel technique is simple and easy to learn and use. The use of a holder eliminates the need to determine horizontal and vertical angulation and also eliminates the possibility dimensional distortion. Parallel technique has great validity, thus, it is easy to use for periodic or serial examinations (Iannucci & Howerton, 2016; Monika, et al., 2020).

The drawback of the parallel technique is its receptor placement. Because this technique uses a holder, receptor placement may be difficult for the radiographer. The difficulty can be found in pediatric patients or adult patients who have a small oral cavity or a shallow palate. However, the main drawback of the parallel technique is that

the holder used to position the receptors in the parallel technique can damage the oral tissues and cause discomfort to the patient (Whaites & Drage, 2013).

In order to anticipate the lack of comfort when used, the authors made a change towards innovation in the holder employed for periapical intraoral examination with this parallel technique. The holder is made with a synthetic rubber or silicone coated on the part that is in direct contact with the patient. Silicone is generally tolerable and safe for the human body because it is non-toxic to both the human body and the environment. Hence, silicone can be used as a material for manufacturing medical equipment (Mojsiewicz-Pienkowska, et al., 2016). By layering the holder with a silicone material that has a soft texture, it is hoped that the patient will feelmore comfortable. Therefore, the authors are interested in conducting a study compiled under the title "Innovation of Dental X-ray Holder Using Silicone Rubber Coating in Posterior Dental Periapical Intraoral Examination".

2. RESEARCH METHOD

This type of research is an experimental with a post-test only design. Research data was collected at the Dental and Oral Hospital, Muhammadiyah University of Semarang in October 2020. The independent variable in this study was the innovation of the dental x-ray holder employing a silicone rubber coating. The dependent variable in this study is the efficiency of the holder uses of radiology officers and the quality of the resulting radiographic image. The control variables in this study were the exposure factor, the tooth region of the examined phantom and the FFD (Focus-Film Distance).

This study has a post-test only research design with control group design. The results of the innovative dental x-ray holder were examined on the cadaveric skull with radiographic imaging, then compared with controls, which was the holder commonly used in hospitals with the Aphrodite type. The object of this study is a periapical radiographic examination holder that has been designed and equipped with a silicone rubber protector on a portion of the image receptor support surface and the bite block.

The sample size is 16, the sample size in this study was determined by Federer's formula. Federer's formula is used to determine the number of repetitions in order to obtain valid data. In this study, because the object of research was an x-ray holder tested on cadaveric skull, the number of repetitions could be interpreted by the number of samples in each group.

The tools and materials in this study were cadaveric skull and dental modalities for GNATUS Periapical X-ray Unit with the RAIOS X TIME 70 E PANT Series. The research instrument employed a questionnaire on a Likert scale with a range of 1–4. With criteria 1. Disagree, 2. Sometimes, 3. Agree, and 4. Strongly Agree. The questionnaire was distributed and filled out by radiographers and dental specialists which had experience in interpreting the results of periapical intraoral radiographs.

The procedure for collecting and processing research data was conducting the Dental Holder Design, starting with the design and manufacture of the holder followed by testing the dental holder. The research data analysis was performed with a Generalized Linear Model with a 95% confidence level (p-value = 0.05) in order to analyze the efficiency of the resulting innovation holder when compared with the control.

3. RESULTS AND DISCUSSION

a. Design Plane

The three-dimensional design of the holder in this study was performed in several stages. The steps which have been taken were starting from performing basic two- and three-dimensional sketches, determining the size and thickness, analyzing three-dimensional geometry, and simulating virtually every part which is designed in three dimensions. The three-dimensional design was mostly conducted on the On Shape application. The output of the design performed is a document or file of the design in the STEP (Standard for the Exchange of Product Data) and STL (Stereo-lithography) format.

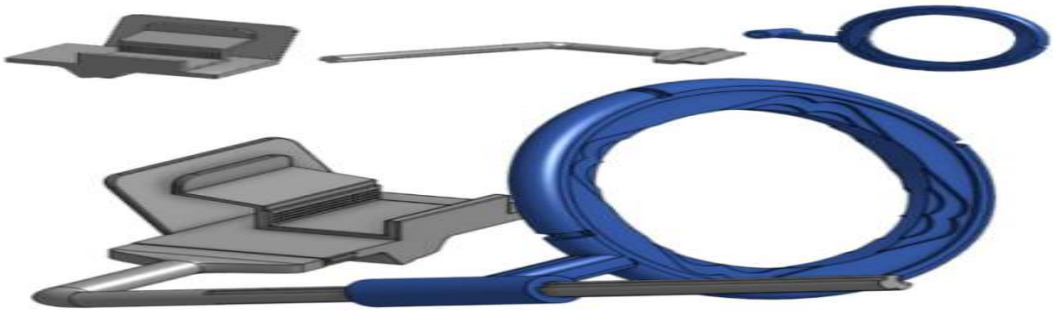

Figure 1. Dental X-ray Holder is the result of innovation employing a graphic processing application.

b. Holder Making

The manufacture of dental holders in this study was administered by a three-dimensional printing process using a three-dimensional printing tool. The printing was performed on a document file with the STL file type. Molding is made with PLA (Polylactic Acid). The PLA material used was food grade PLA, thus, it is safe for use in the oral cavity.

Then, after getting the print results, it was proceeded with the process of making a protective silicone layer on the bite block. The manufacture of this silicone layer was largely through the molding and casting stages. Molding is intended to make food grade silicone molds using molded silicone. Then, the molding results were performed casting, that was inserting food grade silicone material into the molded silicone mold. After that, the print was tidied up and attached to the dental holder which has been made.

After the silicone layer was considered to be in accordance with the design made, it was proceeded to the stage of molding the dental holder with 4 sets of PLA material and then assembling and tidying the print results. Here is Figure 2, which is a set of holders equipped with a silicone layer on the bottom of the holder.

Figure 2. One set of holder + silicone lining on the bottom of the holder

c. Testing

Tests were administered to determine that the holder which has been made efficient is mainly viewed based on the radiographic image displayed. The test was performed employing a cadaveric skull as shown in Figure 3 below.

Figure 3. Position of the test holder against the cadaver of the skull

The test was conducted by exposing the second and third molars to the upper left of the cadaveric skull. The exposition was performed 16 times in each treatment group. The groups given treatment in this study were the innovation group and the control group. The innovation group is the result of an image from the exposure employing a dental holder. Meanwhile, the control group is the image result of exposure using a holder usually used in the Department of Radiology, Dental and Oral Hospital,Muhammadiyah University of Semarang, which is a dental holder with the Aphrodite brand. Furthermore, the results of the radiographic images generated from the exposure are shown in Figure 4 below.

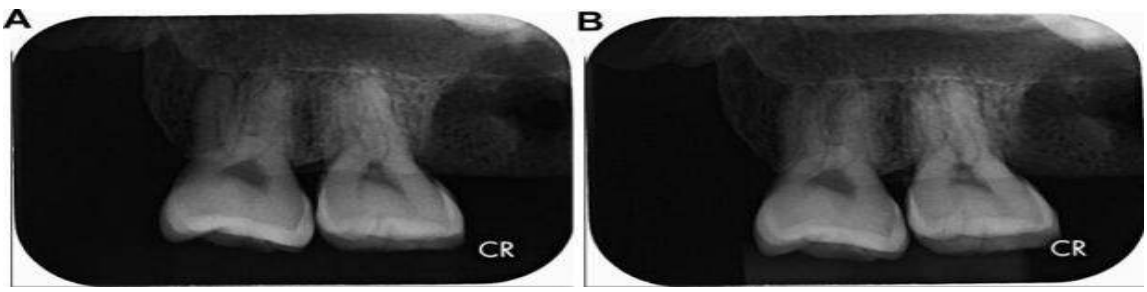

Figure 4. The dental radiographic were produced using (A) Dental holder innovated and (B) Dental aphrodite holder which is commonly used in Department of Radiology, Dental and Oral Hospital, Muhammadiyah University of Semarang.

From the results of the radiographic images produced, then it was assessed by a questionnaire method by a dental radiologist. The assessment by the radiographer was performed to determine the efficiency of using the dental holder. Meanwhile, an assessment by a dental radiologist was performed to determine the quality of the radiographic images produced. In addition, an assessment was also administered on the dental Aphrodite holder which is commonly used in the Department of Radiology, Dental and Oral Hospital, Muhammadiyah University of Semarang. The following is table 1 which is a statistical description of the test results using the questionnaire method.

Table 1. Statistical description of the questionnaire result data.

Testing	Group	Mean	Standard Deviation	N
Work efficiency	Innovation	3.85	0.14	16
	Control	3.72	0.23	16
	Total	3.79	0.19	32
Radiography Image	Innovation	3.80	0.16	16
	Control	3.67	0.10	16
	Total	3.74	0.15	32

Table 1. Shows a statistical description of the data from the questionnaire results of work efficiency testing and radiographic images in the innovation and control groups. Each of which has a sample size of 16, so that the overall average work efficiency and radiographic images are obtained, respectively,3.79 ± 0.19 and 3.74 ± 0.15. In the assessment of work efficiency, the mean results of the questionnaire assessment in the innovation and control groups were 3.85 ± 0.14 and 3.72 ± 0.23, respectively. Based on this value, the average value of the innovation group is greater than the control group.

It shows that the dental holders were made more efficient when usedthe compared to the control group. In the radiographic image assessment, the mean results of the questionnaire assessment in the innovation and control groups were 3.80 ± 0.16 and 3.67 ± 0.10, respectively. Based on this value, the average value of the innovation group is greater than the control group. It shows that the dental holder is better than the control group. However, to assess how much influence and contribution the dental holder made to the work efficiency and radiographic images produced, it is necessary to conduct the further testing.

From the data obtained, the Multivariate General Linear Mode test was then performed to determine how much the percentage of influence and contribution of the dental holder to work efficiency and radiographic images. The following is table 2. the results of the multivariate general linear test data mode questionnaire results.

Table 2. Multivariate General Linear Mode Test Results on Work Efficiency.

Testing	B	Std. Error	Sig.	95% CI	Partial Eta Squared
Dental Holder Innovations	0.125	0.067	0.071	-0.011-0.261	10.5%
Control Group (Aphrodite)					

In table 2, It reveals that the exposed cadaveric skull using the innovative dental x-ray holder with silicone material has a work efficiency value of 0.125 which is more

efficient than the usual holder used in the Department of Radiology, Dental and Oral Hospital, Muhammadiyah University of Semarang. The increase in efficiency is close to significant (p-value 0.071).The use of innovative dental x-ray holders using silicone materials was able to have an effect on the work efficiency value for the radiographer by 10.5% even though this effect was relatively low.

Based on the results of statistical tests, the dental x-ray holder which equipped with a silicone rubber layer had an average value of 3.85 ± 0.14, which means that the radiographer strongly agreed that the dental holder made was very efficient to use. By using this dental holder, the radiographer does not need to intervene too much with the arrangement of x-ray films and tubes. There are several advantages which can be obtained by minimizing intervention during periapical examination. The first is that the radiographer will complete the examination faster.

Cowan, et al., (2013), explained that this shorter examination time can reduce the radiographer's workload and the quantity of examinations which can be performed can increase. It of course provides a very good advantage, considering that the more examinations that can be completed, the more income the hospital will obtain.

Second, the radiographer does not need to intervene too much in the patient's oral cavity. It is in accordance with Ilhan, et al., (2020) that reduced the possibility of disease transmission to or from the radiologist's hand in the patient's oral cavity. Moreover, by reducing interventions in the patient's oral cavity, the patient feels more comfortable and less uncomfortable. The use of dental holders is relatively acceptable. Hence patients do not feel pain. Thus, dental holders are made of environmentally friendly materials and are safe for use in the patient's oral cavity.

The statistical test results also show that the dental holder made a contribution of 0.125 to work efficiency. It means that the innovation applied to the manufacture of dental holders which include the tilt of the film support on the bite block was equipped with a telescopic feature and the use of a silicon coating contributed 0.125 to the great work efficiency of the radiographer. Furthermore, there is also a statistically significant effect on the work efficiency of dental holders made with dental holders which are commonly used in Department of Radiology, Dental and Oral Hospital, Muhammadiyah University of Semarang with a large effect value of 10.5%.

Table 3. Multivariate General Linear Mode Test Results on Radiographic Image Quality.

Testing	B	Std. Error	Sig.	95% CI	Partial Eta Squared
Dental Holder Innovations	0.125	0.048	0.014	0.027-0.223	18.5%
Control Group (Aphrodite)					

In table 3, the results show that the exposed cadaveric skull using the innovative dental x-ray holder with silicone material has a clearer dental radiographic quality value of 0.125 compared to the usual holder used in the Department of Radiology, Dental and Oral Hospital, Muhammadiyah University of Semarang. The improvement in the quality of the dental radiographic is significant (p-value 0.014).The use of innovative dental x-ray holders using silicone materials was able to have an impact on the quality of radiographic images for radiographers by 18.5% even though this effect was classified as low.

Based on the results of statistical tests, the dental x-ray holder equipped with a silicone rubber layer has an average value of 3.80 ± 0.16, which means that radiology specialists strongly agree that the dental holder produces excellent radiographic images. In this study, the assessment of the quality of radiography was performed by assessing the clarity of the apex, crown and pulp anatomy of the teeth as well as the sharpness and shape of the resulting anatomy. The results of this study indicate that the resulting radiographic images show clear dental anatomy with good sharpness and no distortion and elongation when using the dental holder. This provides an advantage for the radiology specialist who performs the interpretation, the sending doctor, as well as for the patient himself (Aps, et al., 2020).

Good quality radiographic images will make it easier for a radiologist to interpret the results. Moreover, good quality radiographic images can reduce the occurrence of errors in making a diagnosis (Aps, et al., 2020). It also affects the sending doctors and the patient being examined. The sending doctor will find it easy to see the results of the radiology specialist's interpretation by seeing the results of the radiographic images. The results of the interpretation made will then be employed to determine the next action to be performed on the patient(Gupta, et al., 2014). Especially in patients who require precise action such as root canal treatment which requires precise measurement of the depth of the tooth root. The measurements will not produce accurate data if the resulting radiographic image experiences distortion and elongation or changes in shape and size (El-Angbawi, et al., 2012; Pando, et al., 2019; Manja & Fransiari, 2018; Khorasani, & Ebrahimnejad, 2017).

If the resulting radiographic image is of good quality, it is possible that errors in interpretation will be minimized. Hence, the sending doctor will also take appropriate action on the problems experienced by patients and are expected to be able tosolve the problems. It gives an advantage to the patient, if the quality of the radiographic images produced is not good, the patient may get inappropriate actions that result in losses for the patient himself.

The advantages of radiographic images generated from the use of this dental holder can be seen from the statistical test results. The results of the statistical test showed that the dental holder made a contribution of 0.125 to the resulting radiographic image. It means that the innovation applied to the manufacture of dental holders which include the slope of the film support on the bite block was equipped with telescopic features and the use of a silicon coating contributed 0.125 to the quality of the resulting radiographic images. In addition, there is also a statistically significant effect on the radiographic image of the dental holder made with the dental holder which is commonly used in the Department of Radiology, Dental and Oral Hospital, Muhammadiyah University of Semarang with a large effect value of 18.5%.

This study provides an innovation for dental radiography examination where the dental holder used for periapical examination is coated with food grade siliconewhich isrelativelysafeforpatient use. This holder is also designed with eco-friendly PLA material so that the price is relatively cheaper compared to market products. The weakness of this study is that the dental holder was designed to be tested on the cadaveric skull only. For further research, a patient can test the comfort of using this dental holder.

4. CONCLUSION

The innovative dental x-ray holder employs a silicone rubber coating which is efficient to use and has good radiographic image quality for intraoral examination of posterior teeth periapical. The authors recommend the use of the dental holder which has been made for intraoral examination of the posterior teeth periapical. However, testing is needed to see how comfortable the dental holder for the patient. Furthermore, it is necessary to develop the design, especially the telescopic system of the beam paralleling ring to make it easier to operate and manufacture of a smaller size dental holder for pediatric patients.

REFERENCES

Aps, J. K. M., Lim, L. Z., Tong, H. J., Kalia, B., & Chou, A. M. (2020). Diagnostic efficacy of and indications for intraoral radiographs in pediatric dentistry: a systematic review. *European Archives of Paediatric Dentistry*, *21*, 429-462. doi: https://doi.org/10.1007/s40368-020-00532-y

Arx, T. V., & Lozanoff, S. (2016). Clinical oral anatomy: A comprehensive review for dental practitioners and researchers. *Clinical Oral Anatomy: A Comprehensive Review for Dental Practitioners and Researchers*. Switzerland: Springer International Publishing. doi: https://doi.org/10.1007/978-3-319-41993-0

Cowan, I. A., MacDonald, S. L., & Floyd, R. A. (2013). Measuring and managing radiologist workload: Measuring radiologist reporting times using data from a Radiology Information System. *Journal of Medical Imaging and Radiation Oncology*, *57*(5), 558–566. doi: https://doi.org/10.1111/1754-9485.12092

Dardengo, C. D. S., Fernandes, L. Q. P, & Júnior, J. C. (2016). Frequency of orthodontic extraction. *Dental press journal of orthodontics*, *21*(1), 54-59. doi: https://doi.org/10.1590/2177-6709.21.1.054-059.oar

El-Angbawi, A. M. F., McIntyre, G. T., Bearn, D. R., & Thomson, D. J. (2012). Film and digital periapical radiographs for the measurement of apical root shortening. *Journal of Clinical and Experimental Dentistry*, *4*(5), e281. doi:https://doi.org/10.4317/jced.50872

Gupta, A., Devi, P., Srivastava, R., & Jyoti, B. (2014). Intra oral periapical radiography - basics yet intrigue: A review. *Bangladesh Journal of Dental Research & Education*, *4*(2), 83–87. doi: https://doi.org/10.3329/bjdre.v4i2.20255

Iannucci, J., & Howerton, L. J. (2016). *Dental Radiography-E-Book: A Workbook and Laboratory Manual*. St. Louis, Missouri: Elsevier.

Ilhan, B., Bayrakdar, İ. S., & Orhan, K. (2020). Dental radiographic procedures during COVID-19 outbreak and normalization period: recommendations on infection control. *Oral Radiology*, *36*(4), 395–399. doi: https://doi.org/10.1007/s11282-020-00460-z

Khorasani, M. M. Y., & Ebrahimnejad, H. (2017). Comparison of the accuracy of conventional and digital radiography in root canal working length determination: An invitro study. *Journal of dental research, dental clinics, dental prospects*, *11*(3), 161-165. doi: https://doi.org/10.15171/joddd.2017.029

Manja, C. D., & Fransiari, M. E. (2018). A comparative assessment of alveolar bone loss using bitewing, periapical, and panoramic radiography. *Bali Medical Journal*, *7*(3). doi: https://doi.org/10.15562/bmj.v7i3.1191

Mojsiewicz-Pieńkowska, K., Jamrógiewicz, M., Szymkowska, K., & Krenczkowska, D. (2016). Direct human contact with siloxanes (silicones)–safety or risk part 1. Characteristics of siloxanes (silicones). *Frontiers in pharmacology*, *7*, 132. doi: https://doi.org/10.3389/fphar.2016.00132

Monika, A. P. W., Astuti, E. R., & Mulyani, S. W. M. (2020). The Quality of The Lollipops Use in The Making of The Anterior Upper Teeth Periapical Radiography of in Paediatric Patients. *Eurasian Journal of Biosciences*, *14*, 4049–4053. Retrieved from http://ejobios.org/download/the-quality-of-the-lollipops-use-in-the-making-of-the-anterior-upper-teeth-periapical-radiography-of-8047.pdf

Pando, J.A.G., Sainz, Z. de la C. T., Reyes, J. C., Concepcion, J. A. C., Santos, I. F. (2019). Effectiveness of Periapical Radiographic Methods by Parallelism and Bisection. *Rev Ciencias Médicas*, *23*(5), 654–663.Retrieved from https://www.medigraphic.com/pdfs/pinar/rcm-2019/rcm195h.pdf

Reynolds, T. (2016). *Basic Guide to Dental Radiography*. Wiley Blackwell.

Whaites, E., & Drage, N. (2013). *Essentials of dental radiography and radiology (5th ed.)*. Churchill Livingstone.

Whitley, A. S., Jefferson, G., Holmes, K., Sloane, C., Anderson, C., & Hoadley, G. (2015). *Clark's Positioning in Radiography* (A. D. Moore (ed.); 13th ed.). CRC Press.