

ASSESSMENT OF RADIATION ATTENUATION BY LEAD AND LEAD FREE APRONS IN THE INTRAORAL RADIOGRAPHIC PROCEDURES- AN EXPERIMENTAL DOSIMETRIC STUDY

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ABSTRACT

Introduction: Radiographic imaging plays a vital role in the diagnosis and management of dental conditions, with intraoral periapical radiography being routinely used in dental practice. Although the radiation exposure from individual dental radiographic procedures is relatively low, repeated exposure necessitate appropriate radiation protective measures due to cumulative effect. The physical features and heaviness of radioprotective aprons may influence their acceptance and usage among dental practitioners. Therefore, evaluation of alternative apron compositions may provide useful information regarding their protection efficiency.

Materials and Methods: An edosimetric study was conducted to assess the radiation protection efficiency of four composition apron materials such as lead, bismuth, bismuth–titanium–zircon, and cloth aprons. Intraoral periapical radiographic exposures were performed at 70 kVp with an exposure time of 0.8 seconds. For each exposure, a mannequin wearing each of the four different apron materials was positioned 2 m from the X-ray source, and the radiation levels were recorded using two digital dosimeters. The measured radiation levels were used to assess the attenuation provided by the different apron materials.

Results: The results demonstrated variation in radiation attenuation among the four aprons used. The bismuth–titanium–zircon apron showed highest attenuation followed by lead and bismuth aprons, whereas the cloth apron demonstrated markedly lower attenuation negligible attenuation. The bismuth apron showed the attenuation comparable to that of lead apron.

Conclusion: The findings demonstrated variation in the radiation attenuation efficiency among four different aprons evaluated during intraoral radiographic technique. The bismuth–titanium–zircon based aprons demonstrated higher attenuation and showed potential as alternatives to lead apron. In contrast, cloth aprons provide inadequate attenuation cannot be considered an effective substitution for radiation protection aprons. Further studies are warranted to evaluate other radioprotective apron materials at different X-ray energies and during various extra oral radiographic techniques.

KEYWORDS: Dental Radiography; Intraoral Periapical Radiography; Radiation Protection; Radioprotective Aprons; Lead Apron; Bismuth; Bismuth–Titanium–Zirconium; Radiation Attenuation; Dosimetry; X-ray Radiation.

INTRODUCTION

As important investigative tool for the assessment of dental structures, radiation plays a vital role in dental practice. In dentistry with the use of X-ray machines there is a capability to locate structures, diagnosis, manage, and plan the treatment for orthodontics, implantology, and also in the endodontics to locate the canals. The ionizing radiation has the disadvantage of radiation hazard but its benefit outweighs in the use of diagnosis and management.¹

Periapical radiography is significant for diagnosing diseases of localized areas of the jaw, such as root canal diseases, periodontal diseases, periapical pathologies, and dental caries and its level of involvement from enamel to pulp. One of the benefits of periapical radiography is the small amount of radiation to the patient due to its localized area of coverage. Effective doses range will also be minimal but it purely depends on the preexposure, during exposure and the post exposure parameters such as processing when a conventional radiographic procedure is followed. Several studies have established that rectangular collimators and digitalization are significant components in reducing radiation exposure to patients and dentists. Such control measures, such as the use of rectangular collimation, can reduce exposure parameter by up to five times in comparison with collimators which are circular type.² However, even with such protection measures, personal protection remains an vital component, particularly through the use of radioprotective aprons. But use of such aprons can significantly affect the comfort, ergonomics and flexibility due to weight of these aprons. Further another component is the long term use of such lead based apron can also pose a health hazard that is lead toxicity. Therefore, this study aims to provide an alternative approach such as lead free aprons to overcome the present limitations of using a lead apron such as weight and toxicity.

MATERIALS AND METHODS:

The study was conducted in the Department of Oral Medicine and Radiology, Best Dental Science College, Madurai. The present study represents a component of a broader investigation evaluating the attenuation of different radioprotective aprons across multiple dental radiographic techniques. The study data were obtained using a mannequin model simulating the operator position during dental radiographic procedures. The mannequin was placed at a distance of 2 meters from the X-ray source in accordance with the National Council on Radiation Protection and Measurements guidelines.³ The mannequin was positioned at a 90° angle to the primary X-ray beam and the distance from the X-ray source was maintained at 2 meters. The distance from the source was measured using the laser distance meter.

Four different aprons were used in the study which included Lead, Bismuth, cloth and Bismuth, titanium Zircon. All three radiation protection aprons used in the study possessed a minimum thickness of 0.35 mm. Appropriate sized aprons were chosen to ensure adequate fit to the mannequin so that to reduce the radiation leakage at those sites.

Radiographic exposures were performed using same standard intraoral periapical radiographic machine for all the exposure. Radiation exposure was measured using two digital dosimeters which include The DSM-10 dosimeter and Radiacode 101 dosimeter. During each radiographic exposure, two dosimeters were placed outside and two inside without overlapping each other. The units of radiation were displayed in the units of milli-Roentgen per hour (mR/h).

Both dosimeters were positioned at the chest level on the mannequin to simulate corresponding position in human. Dosimeters were placed inside transparent pouches to maintain standardized positioning throughout the study. Prior to each procedure, background radiation levels were recorded.

Descriptive statistics were used to summarize the measurements for each apron and were expressed as mean, standard deviation (SD), minimum, and maximum values.

RESULTS:

The present study assessed the radiation attenuation efficiency of four radioprotective aprons used during intraoral periapical radiography (IOPAR). Radiation dose were measured using two different digital dosimeters placed inside and outside the aprons.

Further the study compared lead aprons with Bismuth, Bismuth Titanium Zircon and cloth apron. Radiation attenuation efficiency was assessed for each apron and the transmission doses were analysed.

Table 1 depicts the radiation conducted through aprons during intraoral periapical radiography (IOPAR). Among all the aprons evaluated, Bismuth Titanium Zircon depicted the lowest mean transmission (0.223 ± 0.082 mR/h), which was followed by Lead (0.236 ± 0.065 mR/h). These results suggest that these aprons have superior efficiency among the aprons used in our study during IOPAR exposure. Bismuth also showed better mean transmitted radiation values of 0.248 ± 0.041 mR/h. But, cloth apron depicted higher radiation transmission (2.867 ± 0.178 mR/h).

Table 2 demonstrates the attenuation efficiency of four aprons during intraoral periapical radiography (IOPAR). Among the evaluated aprons, Bismuth Titanium Zircon exhibited the highest attenuation efficiency (92.30%), followed by Lead apron (91.85%). Bismuth apron also demonstrated attenuation efficiency of (91.44%) almost similar to lead aprons. In contrast, cloth exhibited only minimal attenuation, indicating negligible capability against scatter radiation.

Table 1. Radiation Dose inside Different Aprons during IOPAR

Apron Type	Mean Radiation (mR/h)	SD	Minimum	Maximum
Bismuth Titanium Zircon	0.223	0.082	0.026	0.337
Polycotton Cloth	2.867	0.178	2.620	3.240
Lead	0.236	0.065	0.128	0.366
Bismuth	0.248	0.041	0.190	0.314

Table 2. Radiation Attenuation Efficiency of Different Aprons during IOPAR

Apron Type	Mean Inside Radiation (mR/h)	Attenuation (%)
Bismuth Titanium Zircon	0.223	92.30
Lead	0.236	91.85
Bismuth	0.248	91.44
Polycotton Cloth	2.867	1.03

DISCUSSION:

The present study was undertaken to assess the radiation attenuation features of lead and lead free radiation protective aprons during intra oral radiographic procedures. An important finding of the present results are the significance of wearing radioprotective aprons.

The present study represents a component of a broader investigation evaluating radiation attenuation of different radioprotective aprons across multiple radiographic techniques. Therefore, the findings are limited to the four apron evaluated during intraoral radiographic technique.

During intraoral radiographic procedures, Bismuth Titanium Zircon aprons demonstrated the highest attenuation efficiency at 92.30%, which was followed by Lead at 91.85%. This could be due to the performance of Bismuth based aprons which could be due to their atomic number and interaction with photon. However, with this findings it should not be misjudged that the lead free aprons will outperform lead in all the X-ray based diagnostic procedures. As the efficiency of the aprons were tested with low energy X-ray machines with low kilovoltage peak of 70. So the attenuation of different available aprons depends on the energy, and their performance varies according to the tube voltage. McCaffrey et al

demonstrated that lead free aprons vary with their attenuation for diagnostic energies, stressing that these protective aprons vary for the energy of the X-ray machine, rather than assigning a value.⁴

The results indicated that the cloth apron provided negligible attenuation of ionizing radiation and served as a physical covering for the mannequin. Therefore, these findings emphasize the importance of radioprotective aprons in radiology setup.

The results demonstrate differences in the radiation protection provided by lead, lead-free aprons and cloth based materials in radiation protection. Several aprons used demonstrated attenuation while integrating elements such as single or combination of bismuth, titanium and zircon. Such materials are being explored so that it can be used as substitutes to lead based aprons. Lead free aprons may offer blends of elements for radiation attenuation, increase comfort, decrease weight and eliminating the environmental parameters such as lead based toxicity.^{5,6}

The clinical consequence of these results should not be considered as final radiation protection outline as this include only the X-ray machines with lesser energy. Aprons are only a part of radiation protection. Justification of each radiographic diagnosis, optimization of parameters based on the requirement for the patient, following the position distance rule for the protection of the operator, frequent quality assurance for assessment of proper functioning of the X-ray machine and avoidance of multiple exposures for avoidance of unnecessary exposure both for the operator and patient remain indispensable part of radiation protection.

The present findings are so best understood as evidence regarding the attenuation characteristics of the tested materials under controlled conditions. They do not imply that an apron alone can fulfil for other errors such as incorrect radiographic technique or insufficient protection practices.

CONCLUSION:

The study results demonstrated variation in attenuation efficiency among the lead aprons, Bismuth aprons, Bismuth titanium and Zircon aprons and cloth apron during the intraoral radiographic procedure. Overall, the findings of the present study indicate that lead-free aprons can provide radiation attenuation comparable to that of lead aprons during intraoral radiographic procedure. However cloth based material provided inadequate radiation protection and may contribute to the cumulative effect. Further studies are warranted to assess the effectiveness of other radioprotective aprons available in the market and to compare their protection efficiency at different X-ray energies using various extraoral radiographic techniques.

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