

Utilization of rectangular collimation in dental hygiene programs in the United States

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ABSTRACT

Purpose: The use of rectangular collimation during dental radiographic exposure decreases the patient effective dose while improving image quality. The purpose of this study was to assess the extent to which rectangular collimation is being taught in the didactic and laboratory portions of dental radiology courses in dental hygiene education programs. This study also assessed the extent to which rectangular collimation is being used during patient care in dental hygiene programs and identified barriers to its use. **Methods:** Ethics approval was received (HRPO #23-234) in July 2023. A descriptive survey was emailed to 311 United States accredited entry-level dental hygiene program directors. Descriptive statistics, including frequency distributions and percentages, were used to summarize findings. **Results:** Seventy-one responses were received for a response rate of 23%. Results showed that 96% of programs teach rectangular collimation in the didactic portion of the radiology course; 41% teach this technique in the laboratory portion. Only 25% reported using a rectangular collimation device during patient care while 55% stated a "concern for increased occurrence of cone cuts, resulting in retakes" as the primary reason for not using a rectangular collimation device during radiation exposure. **Conclusion:** Although use of rectangular collimation as a patient dose-reduction strategy is taught in 96% of responding dental hygiene programs, concern for retakes was the primary reason students receive limited clinical experience in this technique. Applying learned radiographic techniques clinically could encourage dental hygiene students to continue using rectangular collimation devices after graduation, which would be beneficial for patients.

RÉSUMÉ

Objectif : L'utilisation de la collimation rectangulaire lors des expositions radiographiques dentaires permet de réduire la dose efficace reçue par le patient tout en optimisant la qualité de l'image. L'objectif de la présente étude était d'évaluer l'intégration de cette technique dans l'enseignement théorique et pratique des cours de radiologie dentaire offerts dans les programmes de formation en hygiène dentaire. L'étude visait également à déterminer la fréquence d'utilisation de la collimation rectangulaire dans le cadre des soins cliniques aux patients ainsi qu'à identifier les principaux obstacles à son application. **Méthodes :** L'approbation éthique a été obtenue en juillet 2023 (HRPO no 23-234). Un questionnaire descriptif a été envoyé par courriel aux directeurs de 311 programmes agréés de formation initiale en hygiène dentaire aux États-Unis. Les données recueillies ont été analysées à l'aide de statistiques descriptives, incluant des distributions de fréquence et des pourcentages. **Résultats :** Soixante et onze questionnaires ont été retournés, correspondant à un taux de réponse de 23 %. Parmi les programmes répondants, 96 % ont indiqué enseigner la collimation rectangulaire dans la partie didactique du cours de radiologie, tandis que 41 % l'intègrent en laboratoire. En contexte clinique, seuls 25 % des programmes déclarent recourir à un dispositif de collimation rectangulaire. La principale barrière identifiée (55% des répondants) est la crainte d'une augmentation des erreurs de centrage (« cone cuts »), entraînant des reprises d'images radiographiques. **Conclusion :** Bien que la collimation rectangulaire soit enseignée comme stratégie de réduction de dose dans 96 % des programmes d'hygiène dentaire répondants, son application clinique demeure limitée, principalement en raison de préoccupations liées aux reprises d'exams. Une intégration plus systématique des techniques radiographiques enseignées en contexte clinique pourrait favoriser l'adoption de la collimation rectangulaire par les étudiants après l'obtention de leur diplôme, avec des retombées positives pour la protection des patients.

Keywords: dental radiography; diagnostic imaging; radiation dosage
CDHA Research Agenda category: risk assessment and management

INTRODUCTION

Health care professionals rely on high-quality radiographs as a diagnostic tool for disease detection and management and oftentimes, radiographs are necessary to provide comprehensive care. A rapid growth of medical diagnostic and interventional procedures has been reported by the National Council on Radiation Protection and

Measurements (NCRP).¹ Intraoral radiographs are the most common dental radiograph performed,²⁻⁴ with an estimated 480 million diagnostic dental examinations performed worldwide annually⁵. While conventional dental radiography has been reported to contribute about 0.2% to the overall exposure,^{1,6-7} patients understandably have

PRACTICAL IMPLICATIONS OF THIS RESEARCH

- The benefits of rectangular collimation during radiation exposure are well documented in the literature.
- Hesitation by many American dental hygiene programs to incorporate the use of rectangular collimation devices into the laboratory portion of the radiology course and into patient care experiences may contribute to clinician uncertainty, resulting in excess radiation exposure for the patient.
- Training dental hygiene students throughout their education to expose radiographs while using rectangular collimation devices will improve their technical skillset and encourage its use in clinical practice, benefitting patient care.

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concerns about the safety of radiography and x-radiation exposure. The concept of ALARA (As Low As Reasonably Achievable) isn't limited to the type or amount of exposure but also encompasses technique, technology, and equipment. Therefore, oral health professionals exposing radiographs should adhere to this concept and implement measures to minimize patient radiation exposure. Rectangular collimation, a form of patient dose-reduction strategy,^{2,8-9} restricts the size and shape of the beam from round to rectangular in an effort to mimic the size and shape of the image receptor while reducing the amount of exposure. As an added benefit, rectangular collimation can improve image quality.^{2,10-11}

Modern x-ray units contain a lead collimator within the positioning indicating device (PID) that restricts the size and shape of the beam. This narrowing, or collimation, reduces patient exposure by filtering out the longer wavelengths of the beam reducing scatter radiation.¹² Scatter radiation occurs when the beam passes through a substance, such as body tissues, and deflects in all directions.¹² The deflected radiation is then absorbed by peripheral tissues.^{10,13-14} Dose reduction strategies such as rectangular collimation have been shown to reduce the absorbed dose to organs such as the eyes, thyroid, and salivary glands.^{10,13}

Collimators can be round or rectangular, with the majority being round. Federal regulations in the United States (US) require round collimators to restrict the x-ray beam to 2.75 inches (7 cm).² Rectangular collimators further restrict the x-ray beam to the size and shape of the image receptor, reducing the volume of tissue being irradiated through scatter radiation and improving image contrast.¹⁵

Rectangular collimation limits the amount of radiation dose by at least 40% when compared to round collimation.¹⁴ A rectangular collimation device exposes 70% less tissue volume than that of a round collimator, which causes nearly a 5-fold decrease in the effective dose to the patient.^{16,17} Rectangular collimation can be achieved through receptor holding devices with collimating shields, universal adaptors that attach to round PIDs or by replacement of PID.

The use of rectangular collimation for patient dose-reduction strategies is supported and highly recommended by the American Dental Association (ADA) in collaboration with the Food and Drug Administration (FDA)² as well as the NCRP¹ and International Commission on Radiological Protection (ICRP).⁸ In addition, Health Canada's Safety Code 30¹⁸ states: "rectangular collimation of the x-ray beam must be used, except in occlusal protocols, as it significantly reduces the dose to the patient compared to circular collimation."^{10,14,18-21}

Rectangular collimation increases patient safety^{2,8-9} and produces high-quality diagnostic images,^{2,10-11} yet, the use of rectangular collimation may not be taught²²⁻²³ or used as widely as it is recommended^{1-2,8,18}. The purpose of this study was to assess to what extent rectangular collimation is being taught in the didactic and laboratory portions of the dental radiology course in accredited US dental hygiene education programs. This study also assessed to what extent rectangular collimation is being used during patient care in dental hygiene programs and identified barriers to its use.

METHODS

Approval for this study was granted by the University of New Mexico's Institutional Review Board and the Human Research Protection Office (HRPO #23-234). This study used a descriptive survey with 8 multiple-choice questions adapted and modified from a pilot study.²³ Email addresses for program directors of 311 American Commission on Dental Accreditation (CODA)-accredited entry-level dental hygiene programs were obtained. A recruitment email introducing the purpose of the study and informed consent was sent along with a link to the Microsoft Forms survey. The survey was open to participants for 2 weeks; 1 reminder notification was emailed at the midpoint. In order to participate, the respondent needed to be at least 18 years of age and speak English. If the program director could not complete the survey, the program director was asked to forward the recruitment email to the radiology course coordinator. Those not meeting the criteria were excluded from participation.

The survey included questions asking if rectangular collimation was taught in the didactic portion of the radiology course, as well as in the laboratory portion of the course. For those who were teaching rectangular collimation in the laboratory portion of the course, questions regarding the extent of use during patient care and type of rectangular collimation device were asked. Programs that indicated not using rectangular collimation during patient care were guided to a question focused on identifying barriers to use. The full survey is found in the Appendix. Microsoft Excel was used to summarize the findings through descriptive statistics, including frequency distributions and percentages.

RESULTS

Seventy-one US CODA-accredited entry-level dental hygiene programs responded (N = 71) for a response rate of 23%. Almost all respondents, 96% (n = 68), stated their program teaches rectangular collimation in the didactic portion of the radiology course while less than half, 41% (n = 29), reported teaching radiographic technique using a rectangular collimation device in the laboratory portion of the course. Twenty-five percent (25%) of respondents (n = 18) reported using a rectangular collimation device when exposing radiographs during patient care, with 83% (n = 15) exclusively using a rectangular collimation device. For those using rectangular collimation during patient care, 83% (n = 15) achieved rectangular collimation by changing the shape of the PID through use of a universal adaptor that attaches to a round PID or by replacement of the PID, while 17% (n = 3) used a receptor holding device with collimating shields. When asked how long they had been using a rectangular collimation device when exposing radiographs during patient care, 44% (n = 8) reported using it for more than 10 years. Conversely, 75% (n = 53) of the survey participants reported not using a rectangular collimation device when exposing radiographs during patient care, with 55% (n = 29) stating a "concern for increased occurrence of cone cuts, resulting in retakes" as the primary reason; other reasons included cost of conversion (18%), difficult to use (6%), lack of knowledge

(4%), not beneficial (6%), or OTHER: not used in regional practices (8%) and modern equipment includes rectangular collimator within circular PID (3%) (Figure 1).

DISCUSSION

The benefits of using a rectangular collimator are well documented in the literature.^{10,13-14,16-17} However, there is still a need for more dental hygiene programs in the US to incorporate clinical experiences with these devices into their curriculum. With less than half, 41% (n = 29), of US dental hygiene programs responding to this survey using rectangular collimators during the laboratory portion and an even smaller number, 25% (n = 18), using them during patient care, a significant gap between knowledge and experience exists. The results of this study mimic those of the 2018 pilot study²³ and the 2002 Geist and Katz study²². In both of these studies, students reported receiving limited clinical instruction in rectangular collimation, if any, leaving future oral health care providers inexperienced with this technique. This finding could explain the number of oral health professionals who have not adopted rectangular collimation in practice as seen in previous studies.²⁴⁻³¹

The current study also identified barriers to use. Nearly half of the respondents stated a “concern for increased occurrence of cone cuts, resulting in retakes” as the primary reason for not using a rectangular collimator. While a concern for increased exposure due to retakes is valid, Vijayan et al.³² and Thornley et al.³³ found that, even with retakes, the decreased radiation dose from the rectangular collimator resulted in an overall reduction of effective dose to the patient. Additionally, Senior et al.³⁴ identified that most retakes were prompted by receptor placement errors resulting in missing structures (mesial or distal for bitewings and apical for periapical exposures). While other studies^{23,30-31,33-35} noted a concern for increased cone cuts, a few studies³⁶⁻³⁹ found it rare for retakes to be required as the images were still of diagnostic quality. Identifying common errors allows for new teaching strategies and techniques, such as receptor holding devices, to be implemented which in turn would reduce the number of retakes.

Limitations

The investigators recognize the limited sample of US CODA-accredited entry-level dental hygiene programs represented in this study. Due to this limitation, findings cannot be generalized to all CODA-accredited entry-level US dental hygiene programs, or to programs outside the US.

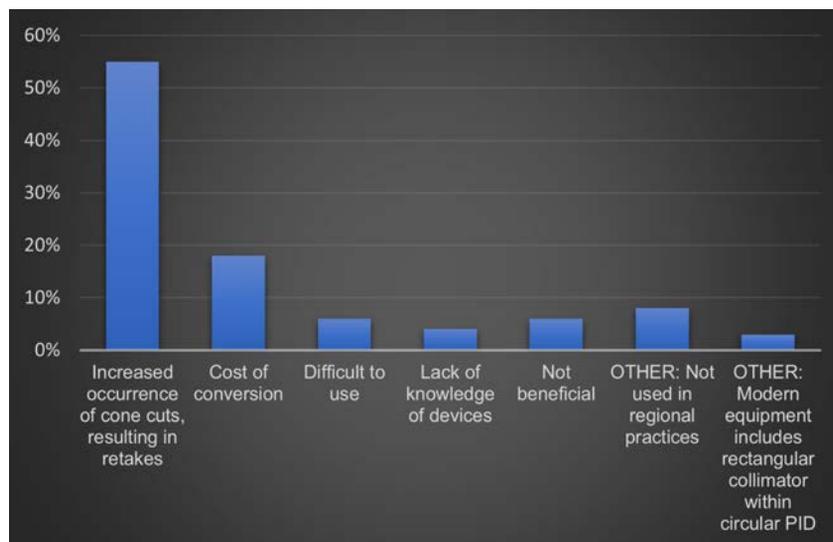
Another limitation is the survey design, which may have led to an inaccurate representation of what is being taught. For example, additional information on what a rectangular collimation device is and how it differs from the modern tube head may have led to a greater understanding of what was being asked. In addition, the inclusion of a demographic question on which area of the US the participants represented would have allowed investigators to identify regional trends. Questions about experience and perceptions of exposing radiographs with rectangular collimation devices may have also provided more accurate information on barriers to use. Furthermore, the incorporation of open-ended questions may have allowed for greater elaboration from participants.

Future studies surveying all oral health professional students (dental assistants, dental hygienists, and dentists) may lead to a more accurate representation of what is being taught in oral health education programs. In addition, future studies comparing the use of rectangular collimation radiographic devices in US and Canadian entry-level dental hygiene programs would also be of interest given that the US Commission on Dental Accreditation and the Commission on Dental Accreditation of Canada have reciprocity between the 2 countries.

CONCLUSION

Research supports the use of rectangular collimation devices as a means of reducing the patient effective dose, while improving image quality for the oral health care provider. Almost all (96%) of the US dental hygiene programs that responded to this survey teach rectangular collimation during the didactic portion of the radiology course. However, less than half (41%) use rectangular collimation

Figure 1. Primary reason for not using rectangular collimation device(s)



in the laboratory portion and even less (25%) use it during patient care. Concern for increased occurrence of cone cuts, resulting in retakes was the primary reason rectangular collimation devices were not implemented during patient radiation exposure (55%). While this study represents a limited sample of US dental hygiene programs, it is important for educators and oral health practitioners alike to recognize that the utilization of these devices aligns with ALARA and best practices. Training dental hygiene students to expose radiographs while using rectangular collimation devices throughout their education will improve their technical skillset, reducing concern for retakes and may encourage professionals to continue with this practice.

CONFLICTS OF INTEREST

The authors do not have any financial, economic or professional interests that may have influenced the design, execution or presentation of this scholarly work.

APPENDIX: SURVEY

- Do you represent an Entry-Level Dental Hygiene Program?
 - Yes
 - No → End of survey
- Does your program discuss rectangular collimation in the didactic portion of the radiology course?
 - Yes
 - No
- Does your program teach radiographic technique using a rectangular collimation device in the laboratory portion of the radiology course?
 - Yes
 - No
- Do students in your program use a rectangular collimation device when exposing radiographs during patient care?
 - Yes → answer questions 5, 6, 7
 - No → answer question 8
- With the exception of occlusal imaging, do students in your program exclusively use a rectangular collimation device when exposing radiographs during patient care?
 - Yes, we only use rectangular collimation
 - No, we use both rectangular and circular collimation
- Which type of rectangular collimation device does your program currently use?

a.		b.	
c.		d.	

e. Other type: _____
- How long has your program utilized a rectangular collimation device when exposing radiographs during patient care?
 - 1-3 years
 - 4-6 years
 - 7-9 years
 - More than 10 years
- What is the primary reason your program does not use a rectangular collimation device?
 - Did not know rectangular collimators were available
 - Concern that rectangular collimators will be difficult to use
 - Concern for increased occurrence of cone cuts, resulting in retakes
 - Concern regarding the cost of rectangular collimator conversion
 - Do not see the benefit of rectangular collimators
 - Other: _____

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