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Assessment of Intraoral Imaging Exposure Rates Among Dental Students: A Cross-Sectional Study on Radiographic Errors and Retake Factors

Pallavi Gadre

S. M. B. T Dental College and Hospital, Sangamner, Maharashtra, India

Abstract: ***A guiding principle of radiation safety is ensuring that radiation dosage is as low as possible while yielding the necessary diagnostic information. The aim of this study was to compare the number of radiographs taken in 'film - based' general dental practices, determine whether conventional radiography resulted in more or fewer radiographs, and analyze the reasons for any changesThe primary objective of this study was therefore to examine the prevalence of and reasons for re - exposure of intraoral images taken by third - and fourth - year dental students in a dental school clinic. All exposures were kept as low as reasonably achievable (ALARA). The total number of intraoral images taken by third - and fourth - year dental students, re - exposures, and error descriptions were extracted from patient clinical records for a four - month period. Out of a total of 9484 intra oral radiographs taken between July and October 2022, 1198 radiographs were repeated due to errors. The maximum number of repeated radiographs were Intra oral periapical radiographs, among those maximum number of patient re - exposures occurred due to cone cutting. Among bitewing radiographs, film misplacement was the most frequently repeating error. For occlusal radiograph, the most common artefact was improper vertical angulation. Errors in taking radiographs increase patient's radiation exposure, and also waste time and money. Educational intervention can now be specifically designed to reduce the retake rate and radiation dose for future patients.***

Keywords: radiation safety, intraoral radiography, image retake rate, dental radiographic errors, ALARA principle

1. Introduction

Worldwide, X - rays are one of the most important diagnostic tools used in healthcare services, despite their association with some radiation exposure to patients[1]. Radiation safety is a crucial concern in dental radiography, where the goal is to obtain the necessary diagnostic information with the least possible radiation dose[2]. The principle of "As Low as Reasonably Achievable" (ALARA) emphasizes minimizing radiation exposure while achieving high - quality diagnostic images[5].

In dental practice, both film - based and digital radiographic methods are employed. However, conventional film - based radiography often leads to errors requiring re - exposure, which increases radiation dose and compromises patient safety. Dental students, particularly in their early years of training, face challenges in identifying and correcting film faults, resulting in repeated exposures. Previous studies have noted that students initially struggle with identifying film faults, but with improved knowledge and training, they develop competence in recognizing and correcting errors[4].

The current study examines the prevalence and reasons for re - exposure of intraoral radiographs taken by third - and fourth - year dental students in a dental school clinic. Understanding the causes of re - exposure is essential for implementing corrective measures, improving radiographic training, and ensuring patient safety. Various scientific and technological improvements, such as the use of fast (E - speed) film and rectangular collimation, can significantly reduce radiation doses by approximately 50% and 60%, respectively[5]. By identifying the primary causes of re - exposure, appropriate strategies can be adopted to minimize errors, optimize radiographic procedures, and promote adherence to ALARA principles.

2. Methodology

The present cross - sectional observational study was conducted in the Department of Oral Medicine and Radiology, targeting routine patients visiting the OPD who required intra - oral radiographic investigations. All repeat intra - oral periapical radiographs (IOPAs) taken between April 2022 and September 2022 were included in the study based on purposive sampling technique. The inclusion criteria consisted of radiographs exhibiting errors and artifacts such as cone - cut, foreshortening, elongation, over - development, under - development, reverse placement of the film, exposure errors, motion blur, bending, overlapping, and other miscellaneous causes. Radiographs that were well - developed and correctly processed, without any errors or artifacts, were excluded from the study (Acharya et al., 2015)[1].

The materials utilized for the study included intra - oral periapical radiographs (IOPAs), occlusal radiographs, and bitewing radiographs. The armamentarium used was an X - ray machine operating at a maximum voltage of 70 kept and a current of 8 mA (Berkhout et al., 2003) [2]. Data collection involved carefully identifying and categorizing all repeat radiographs that exhibited errors based on the inclusion criteria. Each radiograph was meticulously examined for the presence of specific artifacts and errors, and the findings were systematically recorded. The collected data were entered into Microsoft Excel for organization and management, and statistical analysis was performed using SPSS version 21 software. To ensure reliability, the Kappa reliability test was employed to evaluate intra - observer variation. This methodology enabled a comprehensive analysis of the frequency and causes of repeat radiographs, providing insights into common radiographic errors (Vandenberghe et al., 2010)[3].

3. Results

Comparison of Different Factors Responsible for X - ray Retake in Conventional Radiographs

The study analyzed a total of 9, 484 intra - oral radiographs, of which 973 radiographs were repeated due to various errors. The breakdown of errors for Intra - Oral Periapical (IOPA), Bitewing, and Occlusal radiographs is presented in Table 1.

Table 1

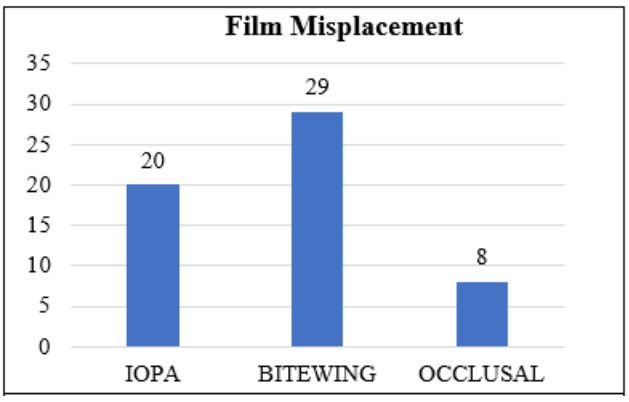
Type of Error	IOPA (n=950)	Bitewing (n=147)	Occlusal (n=35)
Film Misplacement	20	29	8
Cone Cutting	670	49	20
Improper Horizontal Angulation	30	17	-
Improper Vertical Angulation (Elongation/Foreshortening)	100	15	-
Bending	5	7	-
Exposure Errors	20	9	3
Processing Faults	100	24	2
Motion Blur	-	20	-
Thyroid Shield Cut	-	-	-
Total Errors	950	147	35

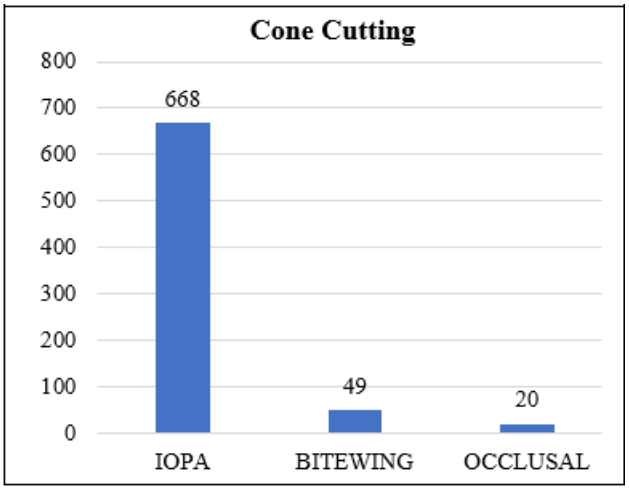
Out of the total 9484 X - rays, the most frequent cause of retake in IOPA radiographs was cone cutting (670 cases), followed by improper vertical angulation (100 cases, including elongation and foreshortening), processing faults (100 cases), and improper horizontal angulation (30 cases). Other errors included film misplacement (20 cases), exposure errors (20 cases), and bending (5 cases).

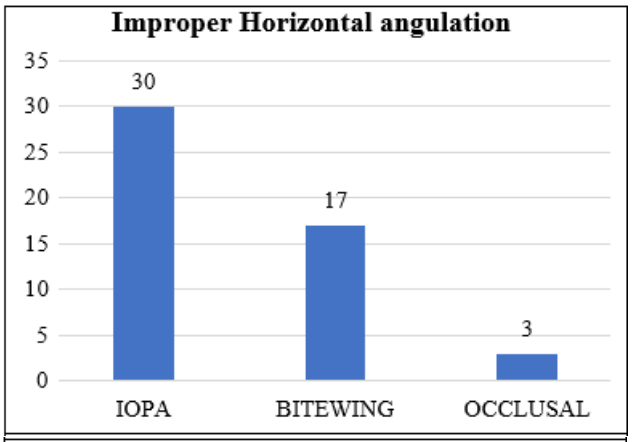
For Bitewing radiographs, the most common errors were cone cutting (49 cases), followed by film misplacement (29 cases), processing faults (24 cases), motion blur (20 cases), and improper horizontal angulation (17 cases). Minor issues included exposure errors (9 cases) and bending (7 cases).

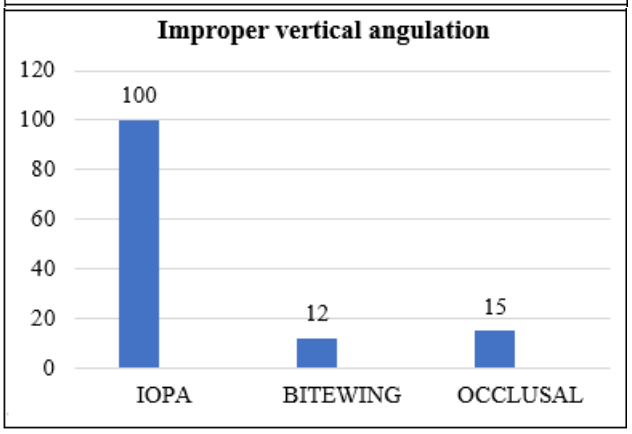
In Occlusal radiographs, errors included cone cutting (20 cases), film misplacement (8 cases), and exposure errors (3 cases).

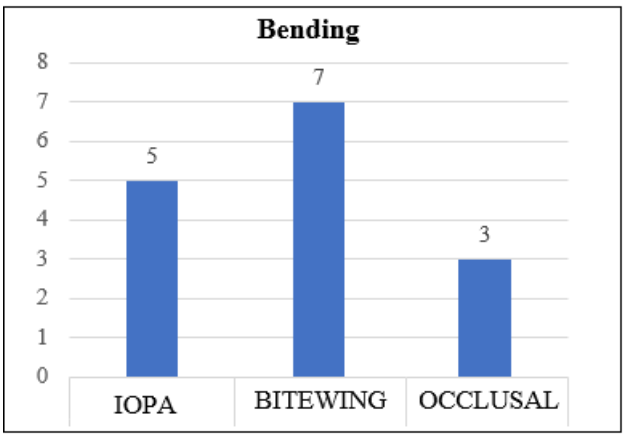
The analysis indicates that cone cutting was the predominant error across all three types of radiographs, particularly in IOPA. Other significant contributing factors included improper angulation, processing faults, and film misplacement.

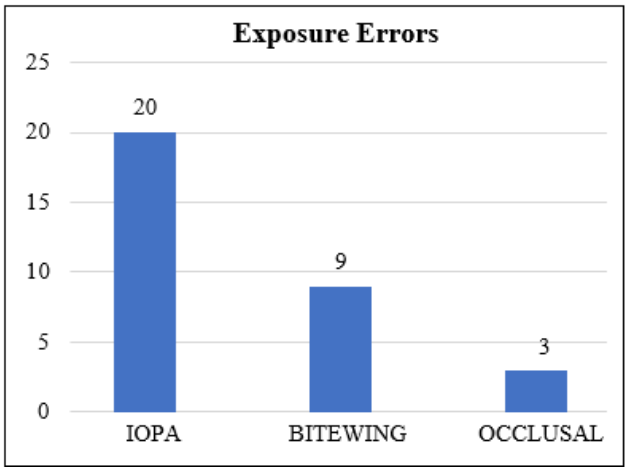


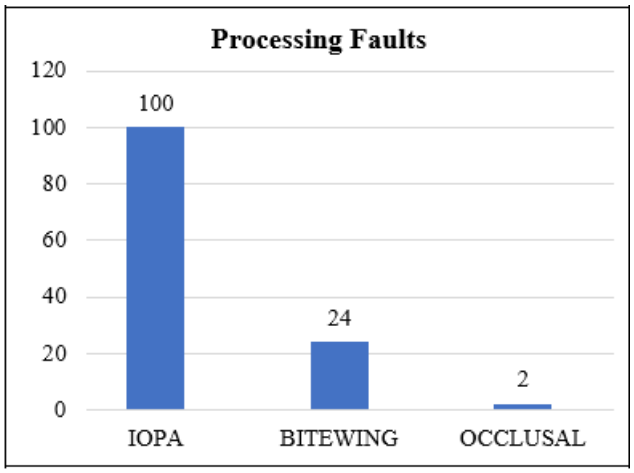


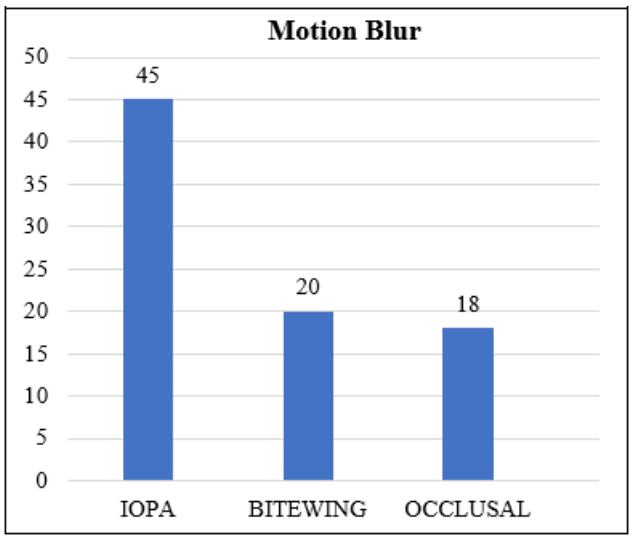












4. Discussion

Dental radiographs are an indispensable diagnostic tool in modern dentistry; however, errors in radiographic technique often result in unnecessary retakes, increasing patient radiation exposure, clinical inefficiency, and resource wastage. Millions of dental radiographic examinations are performed annually worldwide, contributing to a significant collective radiation dose to the population despite the relatively low dose per intraoral image. The core principles of radiation protection—justification, optimization, and dose limitation—emphasize the importance of minimizing retakes and ensuring diagnostically acceptable images on the first attempt (White & Pharoah, 2014)[1].

Our study evaluated the retake rates and common errors among undergraduate dental students, particularly third - and final - year students. The findings revealed that errors were more prevalent in the maxillary molar and premolar regions, followed by the mandibular molar area. This trend mirrors earlier studies, such as Patel et al. (2015)[2], which identified similar problem areas, with mandibular molar and maxillary molar regions being the most common sites for radiographic errors. Incorrect film placement, cone cutting, and processing errors were the most frequent causes of retakes (Acharya et al., 2015; Mupparapu et al., 2007)[3].

The bisecting angle technique showed a higher incidence of cone cuts and exposure errors compared to the paralleling technique. The increased error rates in this technique can be attributed to its reliance on operator judgment for correct angulation and positioning, making it prone to inconsistencies, particularly among less experienced students (Berkhout et al., 2003)[5]. Additionally, processing errors and apical cut - offs were significant contributors to retake rates, underscoring the need for improved precision during receptor placement and beam alignment (Vandenberghe et al., 2010)[6].

A similar study reported a retake rate of 11% in digital intraoral imaging and 4.9% - 7.1% in conventional film - based techniques. Errors such as mesial or distal structures missing, cone cuts, and overlapping contacts have been widely documented, particularly in bitewing images, due to the difficulty in horizontal positioning of the receptor (Wenzel & Møystad, 2010; Berkhout et al., 2004)[7, 8]. Anatomical constraints and patient discomfort, especially with bulkier digital sensors, may exacerbate these errors, leading to retakes (Pachêco - Pereira et al., 2017)[9].

Our findings highlight a key area of concern: students often face challenges in mastering radiographic techniques, particularly when working in anatomically difficult regions such as the posterior teeth. This emphasizes the need for targeted educational interventions to address these challenges. Strategies such as reinforcing preclinical radiographic training, incorporating error identification and prevention sessions, and providing hands - on practice with manikins can significantly improve students' competence and reduce retake rates (Albahiti et al., 2022)[10]. Additionally, real - time feedback from instructors during radiographic procedures can enhance technique accuracy and confidence (Berkhout et al., 2003)[5].

The results of this study provide valuable insight into the types and frequencies of errors made by dental students, which can inform curricular improvements. A targeted approach—focusing on problematic regions (e. g., maxillary molar and premolar areas), common errors (cone cutting, film placement), and challenging techniques (bisecting angle) — can help minimize errors and, consequently, retake rates. By addressing these deficiencies, patient radiation exposure can be minimized, clinical efficiency can improve, and students will develop stronger radiographic skills (Wakoh & Kuroyanagi, 2001; Winand et al., 2016)[11, 12].

5. Conclusion

Errors in intraoral radiography are common among dental students, particularly in challenging anatomical regions and with techniques like the bisecting angle method. Cone cutting, incorrect receptor placement, and processing issues are the leading causes of retakes. Targeted training, error - focused education, and increased hands - on practice can effectively address these issues, improving image quality while adhering to the principles of ALARA (As Low As Reasonably Achievable) to ensure optimal patient safety

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