Repeat film analysis and its implications for quality assurance in dental radiology: An institutional case study

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Abstract

Context: The goal of any radiologist is to produce the highest quality diagnostic radiographs, while keeping patient exposure as low as reasonably achievable (ALARA). **Aims:** The aim of this study was to describe the reasons for radiograph rejections through a repeat film analysis in an Indian dental school. **Settings and Design:** An observational study conducted in the Department of Oral Medicine and Radiology, Manipal College of Dental Sciences, Manipal. **Materials and Methods:** During a 6-month study period, a total of 9,495 intra-oral radiographs and 2339 extraoral radiographs taken in the Radiology Department were subjected to repeat film analysis. **Statistical Analysis Used:** SPSS Version 16. Descriptive analysis used. **Results:** The results showed that the repeat rates were 7.1% and 5.86% for intraoral and extraoral radiographs, respectively. Among the causes for errors reported, positioning error (38.7%) was the most common, followed by improper angulations (26.1%), and improper film placement (11.2%) for intra-oral radiographs. The study found that the maximum frequency of repeats among extraoral radiographs was for panoramic radiographs (49%) followed by lateral cephalogram (33%), and paranasal sinus view (14%). It was also observed that repeat rate of intraoral radiographs was highest for internees (44.7%), and undergraduate students (28.2%). **Conclusions:** The study pointed to a need for more targeted interventions to achieve the goal of keeping patient exposure ALARA in a dental school setting.

Keywords: Dental radiology, dental school, quality assurance, repeat/reject rate

Introduction

One of the basic principles behind a quality assurance (QA)/quality control (QC) program in a radiology department is that it can be a functional and practical means of tracking image quality while taking into consideration the dose to the patient.[1] Repeat film analysis is an integral part of QA/QC program in radiology. The concern carries a significant weight in light of unavoidable stochastic effects in which very minimal radiation doses carry potential risk.[2] Clinically, un-indicated, avoidable repeat, un-optimized examinations may lead to adverse health effects and need serious optimization.[3] Film reject analysis is an important tool for identification of factors associated with suboptimal radiographic images and subsequent rectification.[4] It can provide relevant information to help achieve a reduction in cost and radiation exposure to the patient. In a dental school, this information can assist dental educators to understand the QC issues and limitations within the oral and maxillofacial radiology clinic.

The as low as reasonably achievable (ALARA) principle is fundamental in radiation protection that a dental practitioner can employ within his/her daily practice.[5] This principle becomes all the more important in a Dental Teaching School as appropriate education and training of dental students will help in taking good quality images with minimum repeat rate. The ALARA principle can be difficult to achieve in a dental school setting where repeat radiographs are common. This is understandable, given that inexperienced students are involved. However, when seen on a long-term basis, the economic costs and unnecessary patient exposure to radiation can be substantial in a dental school setting. It is possible to conduct QA audit of the radiographic procedures, so that any systemic weaknesses can be rectified. The advantage of such an audit would be not only the reduction in reject radiographs and patient exposure, but also inculcating good radiographic practices among the students which would be carried over into their professional life.

The aim of this study was to describe the reasons for radiograph rejections through a repeat film analysis in an Indian dental school. The objectives were to estimate the overall repeat rate of radiographs, to assess the prevalence of different type of errors in intraoral and extraoral radiographs, to assess the repeat rate of extraoral radiographs based on the type of radiographs and years of experience of the personnel taking the radiograph.

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Materials and Methods

Repeat film data were collected on every working day from the Dental Radiology Department over a 6-month period and included all plain films (conventional films).

Intraoral radiographs were taken using Kodak 2100 intra-oral X-ray system, and extraoral radiographs were taken using Panmeca Proline 2002CC (Planmeca, Helsinki, Finland). E/F speed film-Kodak E/F speed film Kodak (Eastman Kodak, NY, USA) insight dental film was used to take all the intra-oral radiographs and Kodak T mat film was used for extraoral radiographs. All intra-oral radiographs were taken by bisecting angle technique unless specified (periodontology, implantology). Standard protocol in patient positioning and tube head positioning was followed while taking the radiographs.[6] Rectangular collimator was used to restrict the beam to the size of periapical and bitewing films so that the radiation dose to the patient was minimized. A kilovolt peak setting of between 60 and 70 was used for all radiographs made. Radiographs were processed either manually or using the automatic processor (velopex intra-X processor, velopex, London, UK). All films were examined on a mounting desk where there was adequate and continuous peer review. All dental team members had the requisite training and credentials to take radiographs of dental patients. A log of films that were repeated was maintained. The National Radiological Protection Board (NRPB) recommended that the "dentists should assess the quality of their radiographs as falling into one of three categories."

The criteria for these three categories are: (1) (Excellent) - No errors of exposure, positioning or processing; (2) (diagnostically acceptable) - Some errors of exposure, positioning or processing, but which do not detract from the diagnostic utility of the radiograph and (3) (unacceptable) - Errors of exposure, positioning, or processing which render the radiograph unacceptable. Radiographs showing all the anatomic details with optimum contrast and density and no distortion were considered as excellent. Radiographs with cone-cut or elongation and tooth of interest clearly seen light or dark radiographs, where a diagnosis can still be made, were considered as diagnostically acceptable. Radiographs with large cone-cut, distortion, poor contrast, periapical area not seen, tooth of interest not seen were considered as diagnostically unacceptable. Radiographs falling into Grade 3 were those that should be retaken. With these categories, the NRPB suggested that practitioners should aim to have no more than 10% of their radiographs falling into the Grade 3 category.[7,8]

In all cases, the decision to repeat a radiograph was made by a member of the faculty and the referring doctor was consulted in doubtful cases. The "repeat rate" was defined as the proportion of rejected films in relation to the total number of films exposed.

A record of date, area of interest, method of processing (manual or automatic processor), the error in the radiograph, and the cause of the error were noted. The rejected films were analyzed each day, and the reason for rejection and the type of examination were recorded. Information was recorded about the operator to allow classification into groups according to experience. These groups comprised of radiographers working full time in dental radiology; internees posted in the department for 1-week as a part of their internship program; postgraduate dentists studying for their master's degree in oral medicine and dental radiology; undergraduate dental students attending the department during their first clinical year and faculty members of the department. The errors were grouped into three main categories; personnel error, patient error, and processing error. During the 6-month study period, the observer made a note of all the radiographs that were repeated along with the cause of the error.

Results

A total of 9495 intraoral radiographs and 2339 extraoral radiographs were taken during the 6-month study period, of which the repeat rates were 7.1% (n = 677) and 5.86% (n = 137) for intraoral and extraoral radiographs, respectively. The results showed that the overall repeat frequency for the upper arch was 57% and 42% for the lower arch, and 1% for bitewing radiographs.

Among the causes for errors reported, for intra-oral radiographs, positioning error (38.7%) was the most common, followed by improper angulation (26.1%), and improper film placement (11.2%) [Table 1].

Table 1: Prevalence of different errors for intraoral radiographs

Error*	Prevalence frequency	Percentage
Incorrect horizontal/vertical angulation	176	26
Radiographer error	23	3.4
Improper film placement	76	11.2
Machine error	20	3.0
Tube head positioning error	262	38.7
Processing error	30	4.4
Patient movement	45	6.6
Incorrect exposure factors	17	2.5
Others	28	4.1

*Personnel error: Improper tube head alignment (tooth apex not seen, "cone-cut"), improper film placement (partial image seen, tyre track appearance) improper angulation (elongation, foreshortening, horizontal overlap), improper exposure factors, double exposure, radiograph of wrong quadrant, wrong tooth; Processing errors: Low density radiograph, high density radiograph, streaks on film, reticulation, Stains on films, black film, emulsion peel, blank film; Patient error: Patient movement (blurring of radiographs), periapical area not visualized as patient did not bite on the bite block properly

The study found that maximum frequency of repeats was for panoramic radiographs (49%) followed by lateral cephalogram (33%), Paranasal sinus view (14%), and other skull views (17%) in that order. On comparing the repeat rate of extraoral radiographs against the type of personnel involved it was seen that highest rate of repeat radiographs was by 1-year postgraduate group (48.8%), followed by 2 years' (27.6%), 3 years' (13%), radiographers (8%), and the least by faculty (2.4%). It was also observed that repeat rate of intraoral radiographs was highest for internees (44.7%), undergraduate students (28.2%), and postgraduate students (26%). Staff (0.2%) and radiographers (0.9%) had the least repeat rates [Table 2]. Among the different errors seen on extraoral radiographs, positioning error was the most common (37%) [Table 3].

Discussion

A considerable number of reject/repeat studies have been reported in the literature, with a wide variation in the rates recorded. A review of forty-nine studies reported rates ranging from 3% to 15%.[9] Analysis of the frequency with which radiographs are repeated, gives a measure of the quality of work done in a radiology department. It provides baseline data for quality-control procedures and offers the possibility of reducing exposure of patients to radiation, and of making economies in the use of films, chemicals, and time.[10] The criteria associated with repeating a film is subjective. There is no good way to determine what the repeat rate should be. Each facility should decide on its own, but should strive for a repeat rate of no >5–7%.[11]

We found that overall repeat rate of intraoral radiographs was about 7%. The radiographs were repeated due to a variety of problems, with positioning error being the most common cause for repeating a radiograph. The other causes were improper angulation, improper film placement, patient movement, processing error, and incorrect exposure factors. Studies have shown that radiographs with poor diagnostic quality were as a result of technical errors and inadequate processing.[12-15]

The data showed considerable differences between the repeat rates for different examinations. The intraoral films had a higher repeat rate than the extra-oral films. This could be explained by the fact only postgraduate students and qualified radiographers took the extraoral radiographs. Analysis showed that reject rates of panoramic and lateral cephalometric views were found to be higher than other skull views. Among individual errors in extraoral radiography, positioning error was the most common, followed by improper exposure factors. One possible reason could be that the patient in contrast to intraoral radiography remains in a standing position during the procedure, which can lead to shift in patient position resulting in an error. It would appear that in panoramic radiography, selection of the correct exposure factors is more difficult than it is for the other projections, with a greater element of subjectivity and potential for misjudgement.[12]

In our study, we found that the repeat rate reduced with increasing experience of the personnel taking extraoral radiographs. First-year postgraduates, the least experienced had the highest repeat rates and the staff and radiographers, the most experienced, had the least number of repeats. The study demonstrated that the undergraduate trainees had higher repeat rates than others. It has been assumed that the presence of student radiographers increases the overall repeat rate.[10] Similar results were reported by Mupparapu *et al*.,[16] where it was found that re-exposure rate for the students was

Table 2: Repeat rates of extraoral radiographs

	Frequency	Percentage
According to type of radiograph		
OPG	49	40
Lateral cephalogram	33	27
PNS	14	11
Others	27	22
According to personnel taking the radiograph		
Staff	3	2.4
Radiographer	10	8.1
First-year postgraduate	60	48.8
Second-year postgraduate	34	27.6
Third-year postgraduate	16	13

PNS: Paranasal Sinus; OPG: Orthopantomogram

Table 3: Prevalence of different errors for extraoral radiographs

Error*	Prevalence frequency	Percentage
Extra oral radiographs		
Improper exposure factors	21	17.1
Jewelry artifact	5	4
Improper bite	6	5
Film fog	6	5
Patient movement	16	13
Others	19	16
Positioning error	46	37
Processing error	4	3

Jewelry artifact: Earring or neck chain artifact; Improper bite: Patient biting off center on the lateral incisor or cuspid, bite plane not used; Film fog: Improper storage of films; Patient movement: Patient's shoulders touching the cassette holder during its movement, distortion due to patient movement; Others: Smudge static marking, glove marking, naked tree marking, dark gray fingerprints, white fingerprints; Positioning errors: Head positioned too far ahead in the focal trough, head positioned back in the focal trough, tilted head, off centered bite position, chin positioned upward, chin positioned downward (smiling radiograph), tongue not resting against the palate, prosthesis left in the mouth, lips open, spinal column positioning error, when the cassette is placed backward, only portion of film exposed, double exposure; Processing errors: Low density radiograph, high density and completely black image, roller markings

4.9%, mostly attributed to faulty technique when compared to 0.2% re-exposure rate for staff members.

Repeat film analysis offers a relatively cheap method of QA which causes little interference in routine work and which helps in reducing both radiation dosage to patients and the cost of examinations. QA programs play a vital role in reducing radiation exposure to the patient by improving the diagnostic quality of the radiographs and limiting the repeat radiographic examinations,[17,18] caused by common errors encountred in dental radiology.[19, 20]

The study was helpful in isolating factors leading to additional exposures. The study gave some gross and basic input into the common problems of quality of radiography service. Based on the findings of this study, a regular and continuous QA program can be instituted at all levels of the department for effective health service delivery, patient dose reduction, and sound resource management. Apart from the radiation dose to the public, radiographs which must be repeated, represent additional, nonbillable costs due to increased film, chemistry, and equipment use, as well as increased personnel time. Compounding the overt negative financial impact on the department is an increased burden on the waiting room and support staff. The excess chemicals and the lead foil generated contribute to the environmental pollution.

Conclusions

The results of this study suggest that in order to achieve greater improvements in repeat rates, changes in teaching techniques should be done and teaching should pay particular attention, to the problems of patient positioning. The dental schools play an important role in providing adequate training to the students, so that they can practice the principle of ALARA. The onus is on the dental schools to teach dose reducing strategies to the students so that they will continue to use them in their practice and thus provide radiation protection to the public. It is anticipated that the data obtained from this study will be useful for the implementation of future clinical training protocols for the dental student. Like all audit tools, however, the ability to learn from one's mistakes is fundamental to make the process work.

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