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An Audit on the Quality of Intra-Oral Digital Radiographs Taken in a Postgraduate Paediatric Dentistry Setting

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Abstract

Background: Quality assurance (QA) for radiographs sustains accurate diagnostic information while maintaining radiation doses as low as reasonably achievable (ALARA). **Aims**: To audit the quality of digital intraoral periapical (IOPAs) and bitewings (BWs) radiographs taken in a postgraduate paediatric dentistry setting. **Standards**: The National Radiological Protection Board (NRPB) guidance describes three grades of radiograph quality. Excellent (Grade 1 >70% of total exposures), diagnostically acceptable (Grade 2 <20%) and unacceptable (Grade 3 <10%). **Methodology**: A pilot study was performed on 10 IOPAs and 10 BWs. 50 IOPAs and 50 BWs were reviewed in 2 audit cycles with a 6 month interval (total of 200 X-rays). Results: First Cycle: Of 50 IOPAs: 18 (36%) scored Grade 1, 25 (50%) Grade 2 and 7 (14%) Grade 3. Of 50 BWs: 10 (20%) scored Grade 1, 33 (66%) Grade 2 and 7 (14%) Grade 3. Second Cycle: Of 50 IOPAs: 28 (56%) scored Grade 1, 15 (30%) Grade 2 and 7 (14%) Grade 3. Of 50 BWs: 27 (54%) scored Grade 1, 17 (34%) Grade 2 and 6 (12%) Grade 3. Rejection rate of Grade 3 was analysed in both cycles. A clear improvement in radiograph quality was demonstrated between both cycles, but the standard was not met. **Action plan and recommendations**: Results were disseminated to all staff and recommendations to improve radiograph quality were made to use film holders and paediatric film sizes. **Conclusion**: Although a significant improvement was observed in the 2nd cycle, the overall standard of radiographs fell short of the guidelines. Thus, the quality of radiographs requires continuous auditing to reach the gold standard. An audit spiral is planned.

Key Words: Radiographs, Paediatric dentistry, Quality assurance, Audit

Introduction

Clinical audit is a statutory requirement as well as a useful tool to help you improve your practice or simply check whether or not all members of the dental team meet the expected standards [1]. It can be used for almost any procedure and is required as part of clinical governance for the radiograph [2].

The purpose of a Quality Assurance (QA) audit in dental radiology is to ensure consistently adequate diagnostic information while radiation doses are controlled to be As Low As Reasonably Achievable (ALARA) [3].

Both the current regulations for the use of ionizing radiation for medical and dental purposes "The Ionising Radiations Regulations 1999 and The Ionising Radiation (Medical Exposure) Regulations 2000" (IRR99 and IR(ME)R 2000) [4] place a legal responsibility to establish and maintain quality assurance programme in respect to dental radiology [5]. As part of this, it is necessary to ensure the consistent quality of radiographs through continuous audits. Radiographs must be justified and will only benefit patients if they lead to the correct treatment decision using the minimum radiation dosage [6]. Image quality is important and, if poor, can compromise an accurate diagnosis [7]. It should be remembered that, although an individual patient dose may be low, dental radiographs represent one of the most frequently undertaken radiological investigations in the United Kingdom (UK) [8].

Both retrospective and prospective audits on radiograph quality have been reported in the literature [9-11]. Although the methods of the audits varied, the general issues addressed have been:

- Clinical image quality, where the radiograph contains all the information needed to aid clinical diagnosis.
- Processing quality.
- Record keeping, including mounting, labeling and reporting information in the notes.

Aims

To assess and audit the quality of intraoral periapical (IOPA) and bitewing (BW) digital radiographs taken in postgraduate paediatric dentistry clinics.

Objectives

- Produce consistently high-quality diagnostic radiographs by greater compliance with IRR99 and IR(ME)R 2000.
- Reduce the number of repeat radiographs and costs.
- Determine the sources of error and correct them.
- Ensure radiation doses to patients are as low as reasonably practicable (ALARP).
- To set criteria and standards for good practice and make changes where appropriate and to re-audit on a regular basis.

Standards

The National Radiological Protection Board (NRPB) guidance of UK [12] describes three grades of radiograph quality based on the clinical value of the image. They assign the grades as excellent, diagnostically acceptable and unacceptable. The initial targets of at least 70% excellent and no more than 20%

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acceptable and 10% unacceptable proved rather difficult to achieve *(Table 1)*.

Table 1. Subjective quality rating of radiographs.

Rating	Quality Criteria	Targets: Percentage of radiographs taken
Grade 1	Excellent - No errors of patient preparation, exposure, positioning, processing or film handling.	Not less than 70%
Grade 2	Diagnostically Acceptable - Some errors of patient preparation, exposure, positioning, processing or film handling, but which do not detract from the diagnostic utility of the radiograph.	Not greater than 20%
Grade 3	Unacceptable - Errors of patient preparation, exposure, positioning, processing, or film handling, which render the radiograph diagnostically unacceptable.	Not greater than 10%

Criteria for whether the radiograph needs to be repeated may depend on the specific task it was taken for, or even the degree of concern of your patient regarding excess radiation exposure [5].

Methods

Calibration

The principal investigator was trained and calibrated by an expert oral radiologist, and then intra and inter-homogeneity testes were carried out as follows:

- Intra-Homogeneity was done for the principal investigator on 10 IOPA and 10 BW radiographs using McNemar test. The result was 100% concordance.

- Inter-Homogeneity between the principal investigator and the oral radiologist was conducted using Kappa test on 10 IOPA and 10 BW radiographs and the result was 0.80.

A pilot study of 10 IOPA and 10 IOBW was then carried out to check the methodology, which was found to be sound. Data collection was then carried out.

Total of 100 digital intra-oral radiographs (50 IOPA and 50 BW) that have been supplied from 4 available clinics in paediatric dentistry department were included in each cycle.

The radiographs selected for the 1st cycle were from patients from February 1st, 2015 to April 30, 2015, and for the 2nd cycle were from November 1st, 2015 to January 31st, 2016. (patients were chosen at random from all the 15-paediatric dentistry residents in the department using computer randomization technique).

A well-designed capture form was made and agreed upon by the department. This data capture form as listed below included a list of criteria for the radiograph that we were looking at, to tell you why we were not meeting the standards and which aspects of the process and which team members are meeting the standards, and which are not (rejection rate analysis). If we do not know why we are failing then we will not be able to improve.

- Interdental overlap (yes/no)
- 3 mm of apical bone visible on IOPAs (yes/no)
- Uneven distortion (yes/no)
- The whole tooth visible on IOPA films (yes/no)
- Coning-off (yes/no)
- Good contrast (yes/no)
- Correct exposure (yes/no)
- No corruption (yes/no)
- Mesial of the (6) to distal of the (C) visible on BW (yes/no)
- Inter-radicular visible on BW (yes/no)
- File attached to the correct patient (yes/no)
- Radiograph taken by (dental assistant, dentist)

Each radiograph was then assessed subjectively according to the criteria mentioned above and scored either “1” for “yes” or “0” for “no”, and the total grading was given as either grade 1, 2 or 3 according to the diagnostic quality of each X-ray based on *Table 1*.

Data were analyzed with Statistical Package for Social Sciences (SPSS, version 20, Chicago, SPSS Inc) Software using simple descriptive statistics.

Results

The total number of radiographs selected was 100 intra-oral digital radiographs for each cycle. Fifty IOPA and 50 BW radiographs gathered from 4 paediatric dentistry clinics. Rejection rate of each intra-oral film in both cycles was then analyzed for radiographs that had been graded as “unacceptable” (Gr 3).

Cycle 1: Of the 50 IOPA radiographs, 18 (36%) scored Gr 1, 25 (50%) scored Gr 2, and 7 (14%) scored Gr 3 (*Table 2*). Of the 7 IOPA views that scored Gr 3, rejection rate analysis showed that 80% had proximal overlap, 74% had no visible 3 mm of bone around the apex, and 70% showed the whole tooth was not visible on the film.

Of the 50 BW radiographs, 10 (20%) scored Gr 1, 33 (66%) scored Gr 2 and 7 (14%) scored Gr 3. Of the 7 BW that scored unacceptable (Gr 3), 86% had inter-radicular areas not visible, 70% had mesial of the first permanent molar (6) to the distal of primary canine (C) not visible on the film and 60% had proximal overlap.

Cycle 2: After the results of the 1st cycle were analysed and the new recommendations implemented in the department, a

new set of 100 radiographs consisting of 50 IOPA and 50 BW radiographs were evaluated and graded for the 2nd cycle.

Table 2. Results of cycle 1 and 2.

	Cycle 1		Cycle 2	
Grading	Periapical % (n)	Bitewing % (n)	Periapical % (n)	Bitewing % (n)
Grade 1	36% (18)	20% (10)	56% (28)	54% (27)
Grade 2	50% (25)	66% (33)	30% (15)	34% (17)
Grade 3	14% (7)	14% (7)	14% (7)	12% (6)

Twenty-eight (56%) of IOPA views scored Gr 1, 15 (30%) scored Gr 2 and 7 (14%) scored Gr 3, and of these 14% graded as unacceptable, 90% had the whole tooth not visible on the film, 82% had no visible 3 mm of bone around the apex and 70% had proximal overlap.

The proportion of Gr 1 BW radiographs was 27 (54%), followed by 17 (34%) and 6 (12%) for grades 2 and 3 respectively. When the rejected BW radiographs (unacceptable quality) were analyzed, 76% had 3 mm of crestal bone not visible, 68% had no inter-radicular area visible and in 66% of images, mesial of the first permanent molar (6) and distal of primary canine (C) was not visible on the film.

Discussion

The monitoring of radiographic image quality is a vital part of any quality assurance program looking at dental radiography. The resultant radiographic image is the end result of a series of processes: Positioning the film or sensor within the patient's mouth, positioning the X-ray tube, setting the exposure factors and the development and handling of the exposed film. A fault or inadequacy in any one of these processes will have a resultant effect on the image quality.

Many of the audits done previously showed faults due to positioning errors of either the film or the X-ray tube, which was similar in our audit [9,10,13,14]. Rushton and Horner [15] showed that simple measures such as the introduction of film holders could have a significant effect on the improvement of image quality. The same recommendation was advised in our audit and had a positive impact on the improvement of the image quality in the 2nd cycle.

Emanuel R [9] found in their results that of the 112 radiographs taken, 71% had no processing or developing errors and the majority of errors were due to positioning problems rather than developing, which were similar to our results. Therefore, the use of positioners should be strongly encouraged [6,16,17].

Dental assistants took all the radiographs in our study. Thus, it is a good idea to record the person who was involved in making the exposure as well as the processing, so that good and poor performance can be identified [18].

A high percentage of unacceptable radiographs in this audit could be due to lack of child cooperation during the radiographic examination, which can be improved by more training on how to manage an uncooperative child during radiograph taking [19].

In our study, repeated radiographs were deleted from the patient file in the first cycle. Thus, recommendations were given to keep all the radiographs taken for the patient regardless of how diagnostic is the radiograph. This might explain the low reduction rate of grade 3 radiographs in the 2nd cycle since the unacceptable radiographs were all saved in the patient file without deleting and keeping the radiograph with an acceptable quality.

Unnecessary or repeated radiation carries a significant weight in light of unavoidable stochastic effects in which even very minimal radiation doses carry potential risk [20]. Therefore, it is vital to reduce the number of repeat radiographs to a minimum.

All the radiographs were attached to the correct patient in our study. Much of the focus in dental radiography training is on the correct technique. However, it is no good taking a superb radiograph with perfect positioning and exposure if it is processed poorly, mislabeled or misfiled [21]. This will mean that the radiograph will need to be repeated, unnecessarily raising the radiation exposure for the patient and using up time in practice [20,22]. Therefore, the whole team has a part to play in ensuring that there is a high standard of clinical governance in dental radiography [23].

Recommendations

Results were then disseminated at a departmental meeting and new recommendations were given according to the results as below:

- Use appropriate radiograph for treatment planning.
- Use suitable monitors for viewing digital radiographs, under optimum conditions.
- Receptor-positioning and beam-aiming devices using the paralleling technique and facilitating rectangular collimation should be used for intraoral radiography wherever possible.
- All those involved in radiography should receive adequate theoretical and practical training for the purpose of radiological practices and relevant competence in radiation protection.
- Continuing education and training after qualification is required, particularly when new equipment or techniques are adopted.

- All staff should be trained on how to manage the patients with gagging problems and uncooperative young children.
- Use pediatric film size and ensure that phosphor plates or sensors are in good physical condition before use.
- None of the radiographs should be deleted when repeating an unacceptable quality radiographs.

Conclusions

The overall quality of radiographs was not found to be satisfactory when compared with standard recommendations. Although a significant improvement had been observed in the 2nd cycle after implementing the changes in radiographic devices in addition to modifying the imaging techniques as agreed upon during the departmental meeting and staff education, the quality of radiographs needs to be continuously improved to reach the gold standard.

Setting the target for reaching the standards is the next aspect to consider. A 100% acceptance rate in all aspects of dental radiography is ideal but highly unlikely, especially when dealing with paediatric dentistry patients, where the child's cooperation is of paramount importance. Therefore, a more realistic target set by the NDRB is to provide a high standard of image whilst minimizing radiation, accepting that there will be some errors in imaging.

Carrying out the audit and circulating its results will help raise awareness of quality issues. However, to see whether there is any improvement, the audit needs to be followed up in time.

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