



AUDITING THE QUALITY OF INTRA-ORAL RADIOGRAPHS

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Abstract

Background: Monitoring of radiographic image quality is essential in any quality assurance programme. This audit aimed to investigate the clinical and processing quality of intra-oral periapical (IOPA) and bitewing (BW) radiographs taken at an outreach clinic.

Aims: To audit the image quality of IOPAs and BWs taken at our dental outreach clinic.

Standards: The acceptable standard aimed according to the NRBP and FGDP guidelines for all radiographs to reach was: Grade 1 >70% (Excellent), Grade 2 <20% (diagnostically acceptable) and Grade 3 <10% (Unacceptable).

Methodology: A pilot study was performed on 10 IOPAs and 10 BWs for inter and intra-examiner reliability. 50 IOPAs and 50 BWs were reviewed in 2 audit cycles with an 8-month interval (total of 200 radiographs).

Results: 1st cycle findings: Out of 52 IOPA 1(2%) scored grade 1, 47 (90%) scored grade 2 while 4 (8%) grade 3. Of the 51 BWs taken 4 (8%) scored grade 1, 43 (84%) scored grade 2 and 4 (8%) grade 3. 2nd cycle findings: Out of 25 IOPA 12 (48%) scored grade1, 11 (44%) scored grade 2 whereas only 2 (8%) were grade3. For BWs 14 (55%) were grade 1, 11 (45%) grade 2 whereas none of the BW was graded as grade3. A distinct improvement was observed in the radiograph quality between both the cycles, however the standards still fell short of the guidelines.

Action plan and future recommendations: Action plan and future recommendations: Practical training and lectures were arranged. Recommendations made to improve the radiograph quality included use of paediatric film sizes, collimator alignment and use of phosphor plates in good physical condition.

Conclusion: Substantial improvement was seen in the 2nd cycle. However, the overall standard was still not met. Therefore, continuous staff education along with continuing the audit spiral will help reach the gold standards.

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Introduction:

Dental imaging is important to dentists as a diagnostic aid for proper treatment planning, monitoring of treatment provided and monitoring of lesion development. Poor patient tolerance associated with intra-oral radiography means an excellent image is not always possible particularly in children.

The objective of a quality assurance audit in dental radiology is to ensure consistently optimal diagnostic information is obtained while keeping the radiation doses to be as low as reasonably achievable (ALARA) (Bolas and Fitzgerald, 2009). The 'National Radiological Protection board (NRPB) guidance notes for dental practitioners on the safe use of X-ray equipment (2001)' recommends that radiograph quality is audited on regular intervals. Moreover, both the present regulations including The Ionising Radiations Regulations (IRR) 1999 and the Ionising Radiation Medical Exposure Regulations (IRMER) 2017 implicate legal responsibility for carrying out audits to assess image quality of dental radiographs (IRR, 1999; Rout and Brown, 2012).

Radiographs should always be justified and are only beneficial to the patients if the diagnostic information obtained from the radiograph outweighs the risk associated with a radiation exposure. Several features need to be examined while assessing the overall quality of a dental intra-oral radiograph. These include image geometry, anatomical coverage, density and contrast, focus, processing and equipment factors and lastly collimator alignment. A fault in any of these factors can affect the overall quality of the radiograph and can impede proper diagnosis (BDA, 1997).

Aims:

To audit the image quality of dental intra-oral Periapicals (IOPAs) and bitewing (BWs) taken at the Sir Ludwig Guttman Health and Wellbeing Centre in children.

Objectives:

- To produce high quality radiographs with standards set by the NRPB 2001, the Faculty of General Dental Practitioners (FGDP) 2013 and the European Guidelines on Radiation Protection in Dental Radiology 2004.
- To minimise the number of repeat radiographs
- To identify the common errors and correct them.
- To establish criteria for good practice and make changes where appropriate and to re-audit in 6 months interval.

Standards:

The NRPB (2001) and FGDP UK (2013) guidelines define three grades of radiograph image quality. The grades are outlined as excellent (grade1), diagnostically acceptable (grade 2) and unacceptable (grade 3). According to NRPB and FGDP standards, there should be at least 70% excellent and no more than 20% acceptable and 10% unacceptable dental radiographs (Table.1). (NRPB, 2001; Janssens, 2004).

Retrospective analysis of the IOPAs and BWs radiograph involving quality rating and errors will be recorded using specific criteria adapted from The European Guidelines on Radiation Protection in Dental Radiology 2004.

- Optimal image geometry
- Correct anatomical coverage
- Good density and contrast
- Optimal focus
- Processing errors / Equipment issue
- User error (Collimator alignment) / cone cut

Table.1 Quality rating of Dental Radiographs

Grading	Quality criteria	Standard target
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%

Methods:

- The audit was registered under the clinical governance of Barts and the London school of medicine and dentistry.

- For the 1st cycle a total of 103 digital intraoral radiographs (51 IOPA and 52BW) were assessed. These were taken at the 'Sir Ludwig Guttman Health and Wellbeing Centre' for

paediatric dental patients. The radiographs were viewed using the PACS viewer (SECTRA).

- Out of 51 BW radiographs, 17 were taken by therapists, undergraduate and postgraduate students each. Whereas out of 52 IOPAs, 26 were taken by undergraduate and postgraduate students each. The radiographs selected for the first cycle were from patients from February 1st, 2017 to March 1st 2018.
- For the 2nd cycle 50 intraoral radiographs (25 IOPA and 25BW) were assessed that were taken by the postgraduate students during a period of November 14th 2018 to March 13th 2019. (In contrast to the first cycle, only the radiographs taken by postgraduates were included as the undergraduates and dental therapists did not have clinical sessions at the Gutman hospital during the 2nd audit cycle period).
- Both the primary assessor as well as a paediatric dental consultant were trained by a senior

radiologist on how to assess the quality of radiographs.

- Intra-examiner reliability was done for the primary assessor on 20 IOPA and 20 BW radiographs using the Cohen’s kappa test. The result was 0.90.
- Inter-examiner reliability between the primary assessor and the consultant was carried out again using the Cohen’s Kappa test on 10 IOPA and 10 BW radiographs and the result was 0.82.
- A separate proforma for IOPA and BW radiograph was made including specific criteria adapted from The European Guidelines on Radiation Protection in Dental Radiology 2004 as mentioned below in table 2 and 3.
- Each radiograph was then examined individually as per the criteria mentioned above and finally an overall grading was given as either grade 1, 2 or 3 based on the diagnostic quality (Table 1).
- For a radiograph to be rated as grade 1, all six quality standards must be met.

Table 2 - Proforma for Quality rating of Periapical Radiographs.

PERIAPICAL PROFORMA			
Operator:	TH	UG	
Radiograph number :	PG		
Date			
Radiograph evaluator:			
		Quality scale	Remarks
1.Optimal image geometry	YES NO		
<ul style="list-style-type: none"> • No evidence of bending of the image of the teeth • No foreshortening or elongation of the teeth. • No horizontal overlap. If overlap is present, it must not obscure pulp/root canals. 			
2.Correct anatomical coverage	YES NO		
<ul style="list-style-type: none"> • The film should demonstrate all the tooth/teeth of interest (i.e. crown and root[s]) • There should be 2-3 mm of periapical bone visible to enable an assessment of apical anatomy 			
3.Good density and contrast	YES NO		
<ul style="list-style-type: none"> • Good density and adequate contrast between the enamel and the dentine. 			
4.Optimal focus	YES NO		
5.No processing errors / Equipment issue	YES NO		
<ul style="list-style-type: none"> • Under exposed • Over exposed • Damaged films 			
6. No user error (Collimator alignment)/ cone cut	YES NO		

Table.3 Proforma for Quality rating of Bitewing Radiographs.

BITEWING PROFORMA			
Operator:	TH	UG	
	PG		
Radiograph number:			
Date:			
Radiograph evaluator:			
	Quality scale		Remarks
1.Optimal image geometry <ul style="list-style-type: none"> No evidence of bending of the image of the teeth No foreshortening or elongation of the teeth. no horizontal overlap of more than one half the enamel thickness 	YES NO		
2. Correct anatomical coverage <ul style="list-style-type: none"> Film should cover the distal surfaces of the canine teeth and the mesial surfaces of the most posterior erupted teeth. The periodontal bone level should be visible and equally imaged in the maxilla/mandible, confirming ideal centering. 	YES NO		
3. Good density and contrast <ul style="list-style-type: none"> Good density and adequate contrast between the enamel and the dentine. 	YES NO	YES	
4. Optimal focus	NO	YES	
5. No processing errors / Equipment issue <ul style="list-style-type: none"> under exposed over exposed damaged films 	NO	YES	
6. No user error (Collimator alignment)/ Cone cut	NO	YES	

Results

Cycle 1: For audit cycle 1, 51 BWs and 52 IOPA radiographs were screened. The results for the retrospective analysis using the criteria that were

looked at according to “The European Guidelines on Radiation Protection in Dental Radiology 2004” are stated in figure 1 and 2.

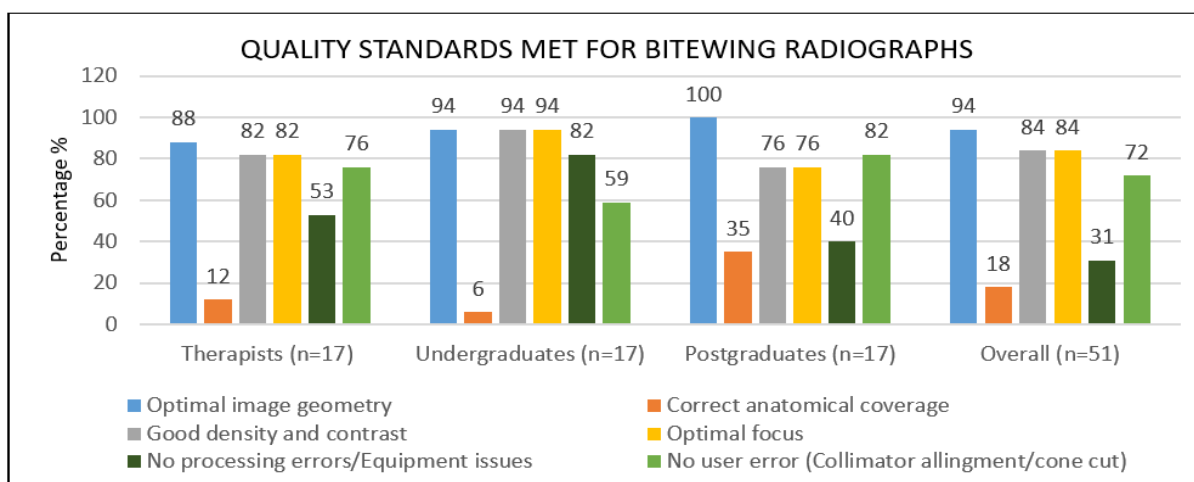


Figure.1 Quality standards for bitewing radiographs

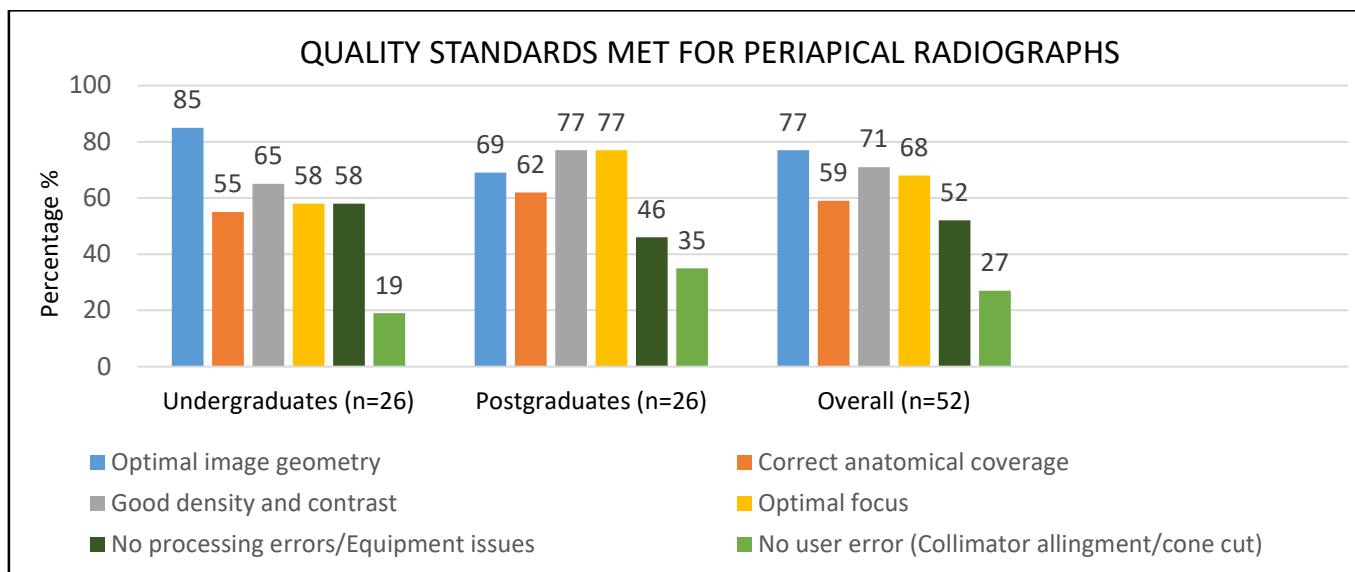


Figure.2 Quality standards for periapical radiographs.

Each radiograph was rated as Grade 1, 2 or 3 according to the “NRPB 2001 guidelines”. The

results for BWs and IOPA radiograph ratings are stated in figure 3 and 4 respectively:

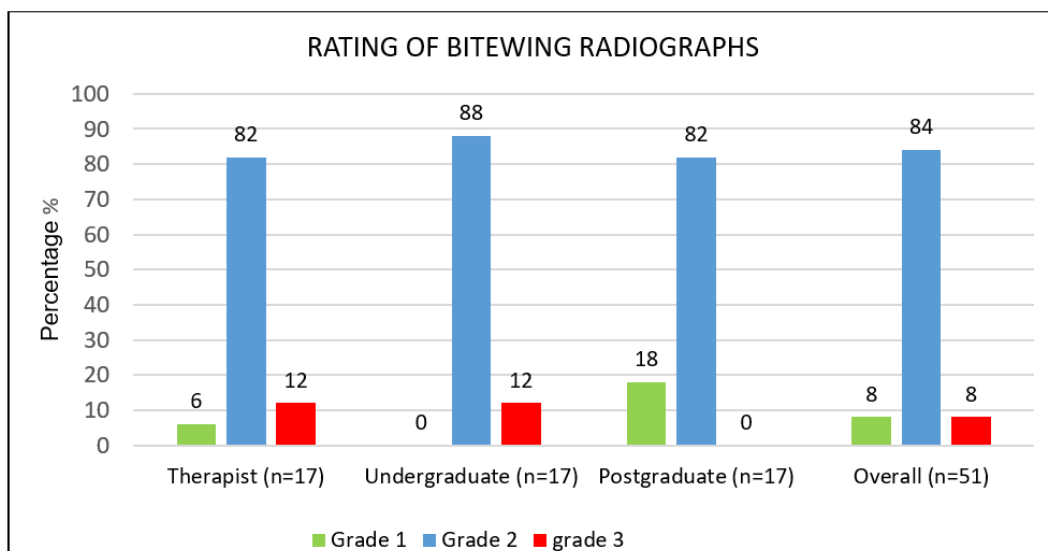


Figure.3 Rating of bitewing radiographs

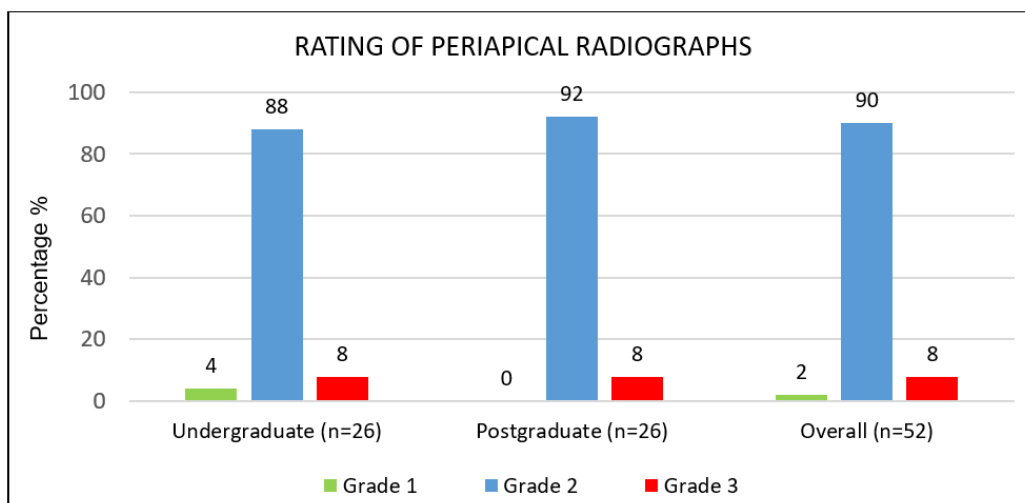


Figure.4 Rating of periapical radiographs.

Cycle 2:

After analysing the results of the 1st cycle and implementing new recommendations, arranging a brief lecture and training session with a senior

radiologist, a new set of 50 intraoral radiographs (25 IOPA and 25 BW) were evaluated and graded for the 2nd cycle.

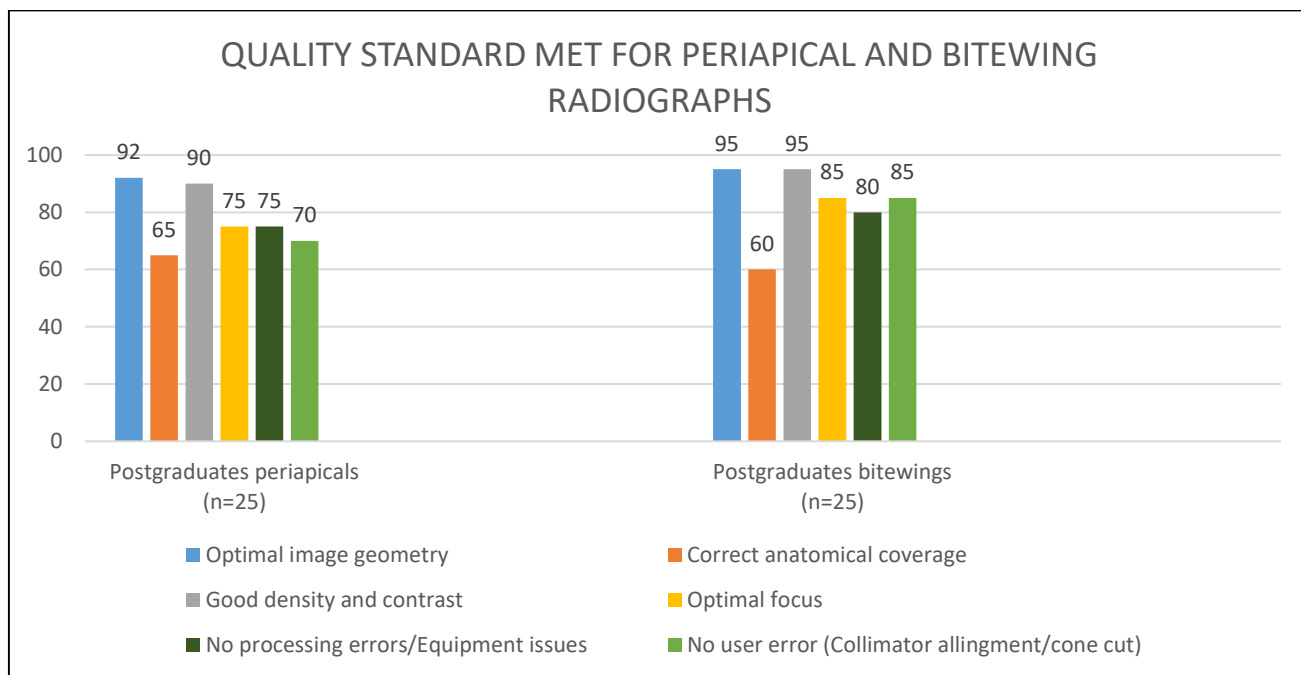


Figure.5 Quality standard for periapical and bitewing radiographs

Grading	CYCLE 1				CYCLE 2	
	Periapical Overall	Bitewing Overall	Periapical PG	Bitewing PG	Periapical PG	Bitewing PG
Grade 1	2	8	0	18	48	55
Grade 2	90	84	92	82	44	45
Grade 3	8	8	8	0	8	0

Figure.6 Rating for periapical and bitewing radiographs.

Discussion:

Assessment of radiographic image quality is essential in any radiology quality assurance program. The resultant intraoral radiographs obtained are the result of series of steps including: selection of the optimal film size, proper film positioning in patient’s oral cavity, positioning the X-ray tube head, adjustment of the exposure settings and development of the radiographic image. Every step requires careful monitoring and problems in any of the step can impact the overall quality of the radiograph.

Based on the results for the bitewing radiographs from the 1st cycle (Fig.3), only 8% were grade 1 where as 84% were grade 2 and 8% grade 3. This showed that the percentage based standards for grade 1 and 2 radiographs set by the ‘NRPB 2001’ guidelines were not achieved in the first cycle of the audit. Majority of the BW radiographs (82%) had compromised anatomical coverage where either distal surfaces of the canine or the mesial surfaces of the most posterior erupted teeth

were not covered, or the periodontal bone level was not equally imaged in the maxilla and mandible. Another major fault was in ‘processing and equipment’ mostly due to damaged films. This was probably because of over usage of the phosphate films. However, when re-audited, the percentage of films with grade 1 rose to 55% whereas 45% of the radiographs being grade 2. A massive improvement was seen in the anatomical coverage following the training of the postgraduate students.

Moreover, during the 1st cycle; of the 52 periapicals 2% scored grade 1, 90% scored grade 2 whereas 8% scored grade 3. Image geometry was compromised in 23% of the IOPAs. This can certainly be improved by using the correct film size for paediatric patients preventing bending of the image of the teeth along with positioning the X-ray tube close to the film to prevent elongation of the image. Additionally, 41% of the periapicals had compromised anatomical coverage where either the crown/ apex was missing, or 2-3 mm of

periapical bone was not visible to enable assessment of apical anatomy. Majority of the IOPAs (77%) also had cone cutting which was probably due to collimator misalignment. Simple measures such as the educating the staff regarding collimator alignment and training sessions focussing on film and X-ray tube head positioning had a significant effect on the improvement of image quality. The same recommendations were advised in our audit and had a significant impact on the improvement of the radiographs quality in the 2nd cycle.

Audits carried out in the past also showed high errors regarding anatomic coverage either due to positioning errors of the film or the x ray tube, which corresponds to our results (Emanuel, 2003; Horner et al. 2008). Although majority of the radiographs were diagnostically acceptable, certain measures need to be addressed for further improvement in the overall quality of the dental radiographs as discussed below.

Recommendations:

- Continuing education and practical training sessions for the hygiene therapists, undergraduate and postgraduate students on areas requiring improvement. Training involving use of phantom head and CPD lectures by senior radiologist on common errors and how to overcome them.
- Ensure phosphor plates are in good physical condition before use. Over use of the films should be avoided.
- Use paediatric film sizes to avoid bending of the image of the teeth.
- All those involved in radiography should receive adequate theoretical and practical training for radiological practices and relevant competence in radiation protection.
- Educating the staff regarding collimator alignment to avoid cone cutting which was seen in high percentage of radiographs taken.
- Re-audit in 6- 8 months interval.

Conclusion:

The overall quality of the intraoral radiographs taken at the 'Sir Ludwig Guttmann Health centre' improved considerably since first cycle of the audit however it was still not satisfactory when compared to the standards set by the NRPB (2001) and FGDP UK (2013) guidelines. Even though a substantial improvement was seen after the 2nd cycle by implementing recommendations, educating the staff about the common errors and arranging training sessions with a senior radiologist, the quality of radiographs needs to be continuously improved to achieve gold standards.

While it would be ideal to meet the standards, taking radiographs for children is also dependant greatly on the child's level of cooperation. Therefore, by discussing the results of the audit in the department, quality issues should be reinforced, and re-auditing should be done every 6-12 months to ensure high standard radiographs are maintained.

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