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An audit of image quality of three dental cone beam computed tomography units

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ABSTRACT

Critical analysis of cone beam computed tomography (CBCT) image quality is recommended as part of a quality assurance program.[1,2] There are few papers[3] in the literature concerning subjective image quality on CBCT imaging.

This study, performed as part of an audit, reviewed all images of the jaws performed on three different CBCT units over a twelve month period. Images were graded according to an agreed standard[1] and reasons for image rejection recorded.

The results demonstrated that the main reasons for image rejection were motion artefact and problems with field of view size and positioning.

The need for reducing the number of rejected images in order to optimize patient dose, and ways to achieve this, are discussed

Introduction

Cone beam computed tomography (CBCT) is an imaging modality which is becoming increasingly popular in dentistry, orthodontics and maxillofacial Surgery. CBCT has evolved from conventional computed tomography (CT). When compared to CT it offers clinicians superior image quality of hard tissues, a lower radiation dose and less metallic artefact.[6] Although the development of CBCT had previously focused on dentistry and its associated subspecialties, the range of clinical applications has widened and it may be used in the assessment of the paranasal sinuses, temporomandibular joints, mid and inner ear disease, interventional radiotherapy and small joint musculoskeletal imaging.[6] For this reason CBCT is being recognised as an alternative form of cross sectional imaging not only in the dental setting but also the general radiology department, with radiographers being central to it being used effectively and efficiently.

As with any imaging modality that involves ionising radiation the need for optimization of patient dose through critical analysis of image quality is essential, and should be included as part of a cone beam computed tomography (CBCT) quality assurance (QA) programme.

Unlike plain film dental radiography, in which film quality is subject to a 3 tiered grading system, it is recommended that CBCT images are graded as either acceptable or unacceptable.[1] A target of 95% acceptable is the suggested standard. Prospective, or retrospective audit of rejected images at regular intervals is a recommended part of CBCT QA.

An assessment of the quality of images taken by 3 different CBCT machines was undertaken over a 12 month period. There has been only one similar published paper on image quality in CBCT imaging.[3] This paper was limited to movement artefact in CBCT imaging. The aim of our study was to grade all CBCT images taken on each unit and identify all reasons for unacceptable image quality.

Methods

This work formed part of an audit. Three different units were investigated namely the i-CAT Classic (Imaging Sciences International, Hatfield, PA), the Next Generation i-CAT (Imaging Sciences

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Table 1
The subjective image quality rating scale and minimum targets for dental CBCT suggested by the health protection agency.

Quality rating	Basis	Target
Diagnostically acceptable	No errors or minimal errors in either patient preparation, exposure, positioning or image reconstruction and of sufficient image quality to answer the clinical question	Not less than 95%
Diagnostically unacceptable	Errors in patient preparation, exposure, positioning or image reconstruction which render the image diagnostically unacceptable	Not greater than 5%

Table 2
Table showing types of faults that may be seen in dental cone beam CT images (based on SEDENTEX CT guidance).

Fault category	Recorded fault category	Observed fault	Cause
Patient preparation	A1	Streak artefacts	Failure to take out removable metallic objects before scanning
	A2	Imaging stent not in the correct anatomical position.	Inadequate care in placing the stent or an ill-fitting stent
	A3	Blurring of Image	Patient movement
Patient positioning	B1	All, or part of, the area of interest excluded from the scan volume	Failure to position the scan volume over the area of interest during preparation
	B2		Patient movement between initial positioning and exposure
	B3		Field of View too small for the diagnostic task
Exposure	C	Increased 'graininess' and reduced sharpness of the image	Exposure factors too low (kV, mA, reduced number of basis images)

Table 3
Overall rejection rate from the 3 CBCT units.

Dental CBCT unit	Number of scans acquired	Number of scans rejected	Percentage of images rejected
i-CAT classic	339	15	4.4
Next generation i-CAT	99	5	5.1
Accuitomo 3D FDP	573	9	1.6

International, Hatfield, PA), and the Accuitomo 3D FDP (J. Morita MFG. Corp, Kyoto, Japan).

The image quality of all the images produced on 3 CBCT units was assessed using the subjective 2 point scale suggested by the Health Protection agency (HPA)[1] (Table 1). A single suitably trained radiographer rated the images for the Next generation i-CAT and the Accuitomo 3D FDP and a different radiographer with a similar background assessed the quality of images produced on the i-CAT Classic. The scans for the same 12-month period were assessed for each unit.

When images were given a grade 2 and repeated, the error type for the rejected images was recorded and categorised based on guidance produced by the SEDENTEX CT group (Table 2).[2]

For the i-CAT classic a variety of imaging protocols was used. In all cases the kV and mA were fixed. The scan time chosen was either 20s or 40s and the height of the imaging volume ranged from 4 cm to 13 cm. In all cases the diameter of the imaging volume was 16 cm. For the Next Generation i-CAT a variety of imaging protocols was used. In all cases the kV and mA were fixed. The scan time chosen was either 20s or 40s; the diameter of the imaging volume was 16 cm in all cases and the height of the imaging volume ranged from 4 cm to 17 cm. For the Accuitomo 3D FDP a range of imaging protocols was used, with 4×4 cm, 6×6 cm and 8×8 cm imaging volumes used. The kV was fixed at 90 kV with the mA ranging from 3 to 5 mA and all performed with 360° capture.

Results

A total of 339 scans were acquired on the i-CAT Classic (159 male 180 female, mean age 26 years,range 5–78), 573 on the Accuitomo 3D FDP 28 (264 male 309 female, mean age 28,range 5–83) and 98 on the Next Generation i-CAT (43 male 55 female, mean age 40, range 7–80). Only scans performed for dental reasons, i.e.: of the maxilla and mandible were included. Scans of the temporomandibular joints, orbits, ear and paranasal sinuses were excluded.

The overall rejection rate is shown in Table 3. Table 4 shows the rejection rate when examined by region scanned. The types of errors rendering the images diagnostically unacceptable are shown in Fig. 1.

Blurring of the image is related to patient movement, so it can be hypothesised that the longer the exposure the more chance there is of getting a movement artefact. Table 5 shows the total scan time for the scans used for each unit and the number of blurred images for each scan time. Similarly it would be expected that movement artefact may be more likely to be seen in children so we looked at differences in rejection rates between scans performed in adults and children (Table 6).

Table 4
Rejection rate when examined broken down by the region scanned.

	Mandible			Maxilla			Mandible and maxilla		
	Number of scans	Number of scans rejected	% of scans rejected	Number of scans	Number of scans rejected	% of scans rejected	Number of scans	Number of scans rejected	% of scans rejected
i-CAT classic	66	1	1.5	245	13	5.3	28	1	3.6
Next generation i-CAT	29	1	3.4	35	2	5.7	35	2	5.7
Accuitomo 3D FDP	367	5	1.4	205	4	2.0	1	0	0