COVID-19 and beyond: implications for dental radiography

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Key points

- The avoidance of intraoral radiographs during COVID-19 has been recommended due to the potential of inducing a patient aerosol.
- Extraoral bitewings were found to be a suitable alternative to sectional panoramic radiographs as they provided high-quality images with a lower radiation dose.
- Recommendations are suggested for the use of extraoral bitewings post-COVID-19.

Abstract

Due to the coronavirus pandemic, all routine dental care in the UK ceased on 25 March 2020. Liverpool University Dental Hospital (LUDH) responded by commencing an emergency dental service on the same date. Clinicians were redeployed within the Hospital to meet the needs of the service, including staffing of the radiology department. LUDH followed Royal College recommendations by taking extraoral radiographs in preference to intraoral radiographs due to the risk of inducing an aerosol. Issues were identified with clinical diagnosis from sectional panoramic radiographs, which led to the introduction of extraoral bitewings being taken as an alternative. A quality assurance audit found that these images provided a substantially lower radiation dose and produced excellent quality images with improved diagnostic accuracy. This article aims to summarise how our radiography practices changed in response to the coronavirus and how the lessons that we have learnt provide an opportunity to modify and improve future practice, beyond the pandemic.

Introduction

Due to the coronavirus (COVID-19) pandemic, Liverpool University Dental Hospital (LUDH) ceased routine dental care on 18 March 2020 following advice from NHS England.1 It became one of the first emergency dental care providers in the UK from 25 March 2020 for patients aged 16 and over, before the establishment of urgent dental centres. In the first eight weeks of the service, there were approximately 3,000 telephone calls triaged, 1,500 patient attendances and 1,250 radiographs taken. The majority of the LUDH radiographers were redeployed as part of the Trust’s response to COVID-19, and so consequently, LUDH clinicians who were part of the emergency dental team staffed the radiography department following training.

During COVID-19, the Royal College of Surgeons of England advised that radiography should be kept as simple as possible in order to minimise staff-to-patient contact, while providing diagnostic quality radiographs.2 The recommendations state that sectional or full-width dental panoramic (DPT/OPG) radiography should be considered as the first line of imaging and it should be adequate for managing patients in acute settings, where only emergency treatment is being provided. Intraoral radiographs should be taken with caution due to the potential to cause a patient aerosol from coughing, gagging, retching or vomiting.

The LUDH radiography department has two panoramic machines capable of taking sectional radiographs (Instrumentarium Orthopantomograph OP200D and OP300). During the first couple of weeks of the emergency service, sectional panoramic radiographs were taken; however, diagnostic problems were identified when the tooth causing the dental pain was not always clear from the images, especially in heavily restored dentitions and where there was crowding in the buccal segments. Gijbels et al.3 reported that the premolar region in the upper jaw is the region where further radiographs can be needed in addition to a conventional panoramic radiograph. The LUDH machines have a bitewing setting but, unlike intraoral bitewings, the apices of the teeth are visible (Fig. 1). The bitewing function on a dental panoramic machine is an orthogonal view, which opens up the contact points better than a conventional panoramic radiograph of the same area by using improved interproximal angulation projection geometry.4 Figure 2 shows a patient with pain in the 25/26 region who had an extraoral bitewing taken following an undiagnostic sectional panoramic radiograph. The extraoral bitewing was much clearer, and so consequently, the team felt that these images were a better alternative to sectional panoramic radiographs for diagnosing problems in posterior teeth.

In line with UK legislation, radiation doses should be kept as low as reasonably practicable (ALARP) while maximising diagnostic benefit.5,6 As quality assurance is central to these regulations, an audit was undertaken to assess the introduction of this alternative technique.
Aim

To assess the quality of sectional extraoral radiographs taken at LUDH during the COVID-19 pandemic, and to identify possible areas for change and improvement.

Standards

The standards used in this audit were based on the image quality rating system and performance targets set by the National Radiological Protection Board guidance notes (Table 1). The criteria were applied in particular reference to the tooth/teeth requiring investigation rather than to the overall image. However, on every occasion, the clinical data from the whole radiograph was analysed and reported by the referring clinician.

Methods

A retrospective audit to assess the quality of all sectional extraoral radiographs taken during one week of the COVID-19 emergency dental service at LUDH (13–17 April 2020). The audit was registered with the Trust and the following data were recorded for each patient: type of radiograph, tooth of interest, quality rating (with reasons when grade 2 or 3), radiation dose area product and any extra areas of exposure outside the target field of view. The radiographs were assessed by an experienced radiographer and a clinician.

Dose area product (DAP) is a quantity used in assessing radiation risk and is defined as the absorbed dose multiplied by the area irradiated, expressed in milligrays per square centimetre (mGycm²). DAP reflects not only the dose within the radiation field but also the area of tissue irradiated. The DAP has been used in this audit as the figures are displayed by the machines at the end of the examination. However, when considering the patient dose for a particular projection, it is normally the effective dose which is quoted as this takes into account the sensitivity of the tissues that have been irradiated.

Results

Over the data collection period, 108 sectional extraoral radiographs were taken; 58 extraoral bitewings and 50 sectional panoramic radiographs (Table 2). There was a fairly even split between left- and right-sided radiographs (51% right; 49% left). Overall, 92% of the radiographs taken were of excellent quality, 7% were diagnostically acceptable and 1% were unacceptable. Only one radiograph was deemed grade 3 as the apex of an upper molar was not visible. The clinical reason for the image was to assess the root morphology before extraction, but the clinician did not

Fig. 1  a) Example of an intraoral bitewing. b) Example of an extraoral bitewing on OP300 panoramic machine

Fig. 2  a) Sectional panoramic radiograph. b) Extraoral bitewing for the same patient showing the differing field of view and improved separation of contact points

Table 1 Diagnostic quality rating of radiographs and performance targets (reproduced with permission from Public Health England)

| Rating         | Quality                        | Performance targets |
|----------------|--------------------------------|---------------------|
| 1              | Excellent                      | Not less than 70%   |
| 2              | Diagnostically acceptable with minor error | Not greater than 20% |
| 3              | Unacceptable/non-diagnostic    | Not greater than 10% |

Table 2 Radiation doses and quality ratings

| Type of radiograph          | Panoramic machine | Average DAP (mGycm²) | Number of images (%) | Quality rating | Total |
|-----------------------------|-------------------|----------------------|----------------------|----------------|-------|
|                            |                   |                      |                      | 1   | 2     | 3     |         |
| Sectional panoramic radiograph | OP200D          | 24.6                 | 23 (85)              | 4 (15) | 0 (0) | 27 (25) |
|                            | OP300            | 73.2                 | 22 (96)              | 1 (4)  | 0 (0) | 23 (21) |
| Extraoral bitewing         | OP200D          | 11.9                 | 18 (85)              | 2 (10) | 1 (5) | 21 (20) |
|                            | OP300            | 32.1                 | 36 (97)              | 1 (3)  | 0 (0) | 37 (34) |
| Total                       |                   |                      |                      | 99 (92)| 8 (7) | 1 (1)  | 108 (100) |
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require a further image in this instance. Eight radiographs were deemed to be grade 2; one radiograph did not include 3 mm of bone above the maxillary molar apex, two images were blurred and five were not sharp. From the five radiographs that were not sharp, two of the images were also grainy.

There was a difference when examining the results based on the panoramic machine; 85% were grade 1 for OP200D and 97% were grade 1 for OP300. However, there was little or no difference in the quality of images when comparing extraoral bitewings and sectional panoramic radiographs for both machines. The average DAP for an extraoral bitewing was less than half that of a sectional panoramic radiograph for both machines. The DAPs on the OP200D were lower than the OP300 for each type of radiograph.

Sixty-eight percent of sectional panoramic radiographs had a greater field of view taken than was clinically necessary. Half of the sectional panoramic radiographs had the condyles included, 36% included the anterior section (canine-canine) and, in 22% of the images, the orbit was partially visible.

Discussion

It is encouraging that the results well surpassed the audit standards in terms of image quality. The OP300 machine is the updated model of the OP200D machine; therefore, it may not be surprising that it outperformed its predecessor in terms of radiographic quality. The images were sharper and less granular. The grade 2 images taken on the OP300 machine were due to blurring, which is most likely to have been caused by patient movement during the exposure.

At LUDH, the bitewing setting had rarely been used before the COVID-19 pandemic, due to intraoral bitewing and periapical radiographs being standard practice. With increasing experience of taking bitewings on both the OP200D and 300 machines, it became apparent that, on the OP200D machine, the apices of the upper posterior teeth would be missed off and would therefore be undiagnostic and of grade 3 quality (Fig. 3). This is likely to be a localised issue with this model of machine as the chin rest does not lower for a bitewing setting. In the OP300 machine, the chin rest lowers compared to the tube head and sensor, which reduces the angulation of the x-ray beam and makes it more perpendicular to the teeth and sensor. The areas conventionally visible on an extraoral bitewing setting are the premolars, molars, the bottom of the maxillary sinus, the mandibular canal and the mental foramen. From our experience, the images did not always capture the first premolars in patients with larger jaws. A 2/5 sectional panoramic radiograph was therefore taken in preference for first premolars, which included the anterior segment but not the condyle, to avoid the need for possible further exposure (Fig. 4).

A study by Abdinian et al. showed that extraoral bitewings were superior to conventional panoramic radiographs for detection of proximal caries. In the literature, there are contrasting views regarding the use of intraoral and extraoral bitewings for detection of proximal caries; there is evidence to support intraoral bitewings being better, evidence of no difference and evidence that states extraoral bitewings are the preferred method.

Once panoramic radiographs have been taken, dental imaging software can be used to enhance images before saving them to a picture archiving and communication system. The adjustment of image contrast and density in post-processing can potentially improve the quality of the radiographs, along with other filter adjustments such as sharpen and noise reduction. There have been mixed opinions in the literature about whether post-processing enhances the image; a few studies found post-processing had no effect on the quality but our experience aligns with the majority of studies that find post-processing enhances the image quality. Harvey et al. reported problems of ghost artefacts in a couple of case reports when using ‘non-standard’ panoramic programmes, like the bitewing setting, but we found no such issues. A minority of clinicians initially expressed a preference to conventional sectional panoramic radiographs rather than extraoral bitewings, but this was due to lack of familiarity when viewing the images and the early images were sometimes a little blurred. The sharpen function was subsequently used to enhance the radiographs using CLINIVIEW software and this post-processing resolved the issue. However, care must be taken as multiple sequential sharpening operations may degrade the image quality and cause excessive artefacts.

National Diagnostic Reference Levels (NDRLs) are an indicative dose that is not expected to be exceeded under normal imaging conditions. The current NDRL in the UK for an adult full panoramic radiograph is 81 mGy.cm². All images taken at LUDH were under this. The dosage was significantly higher on both the bitewing setting and sectional panoramic setting for the OP300 machine compared to the OP200D machine. On discussing this finding with the radiographers, it was discovered that this difference would not usually be so great, as they routinely manually increase the kilovoltage (kV) and milliamp (mA) on the OP200D machine in order to improve image quality. Due to the short-notice redeployment of the radiographers, emergency dental staff were trained to safely use the machines with standard settings and finer adjustments were beyond the scope of training. This may have accounted for a higher number of grade 2 images on the OP200D, with a grainy appearance occurring due to the settings being slightly low.
The extraoral bitewing setting reduced the radiation dose by more than 50% on each respective machine compared to the sectional panoramic radiographs, in line with the ALARP principle. This is in accordance with Lecomber and Faulkner who reported that, by limiting the radiograph to the tooth-bearing region of the jaws, the effective dose could be reduced by more than 50%. To allow comparison, Table 3 shows the average DAP for extraoral and intraoral (Instrumentarium Focus) bitewing radiographs for both adult and paediatric patients. The figures demonstrate that the radiation doses are very similar for extraoral and intraoral bitewings, particularly when round collimation is used.

At the beginning of the COVID-19 pandemic, emergency dental service clinicians were working in unfamiliar settings in both the radiography department and the emergency dental department. If the clinical history on the radiography request form was not specific, a 3/5 left-or right-sided panoramic radiograph was taken, rather than a more focused sectional view. Approximately two-thirds of the sectional panoramic radiographs therefore had a greater field of view taken than was necessary. Subsequently, information was communicated to all clinicians on the importance of specifying the symptomatic tooth/teeth to ensure that the radiation dose was justified and ALARP. The Ionising Radiation (Medical Exposure) Regulations (IR[ME]R) practitioner is responsible for the justification of the medical exposure, and in a hospital setting, the clinician is the IRMER referer and the practitioner is usually a member of staff within the radiology department.

The adult panoramic radiograph setting on the LUDH machines has a large field of view, which can be reduced in a transverse direction by deselecting fifths. Fifty percent of sectional panoramic radiographs included the condyles in the field of view, which is potentially unnecessary radiation exposure if only a dental problem is being investigated. Condyles should only be included for cases such as suspected temporomandibular joint (TMJ) pathology or trauma. It was identified that the orbit was partially visible in 20% of (TMJ) pathology or trauma. The figures demonstrate that the radiation doses are very similar for extraoral and intraoral bitewings, particularly when round collimation is used.

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intraoral periapical radiograph would usually be taken or if multiple teeth are symptomatic in a posterior quadrant(s)

- Remove the condyles from the field of view for any sectional panoramic radiograph if there is no TMJ pathology noted, or simply reduce the field of view to the tooth-bearing region of the jaws

- Post-COVID-19, consider extraoral bitewings as an alternative to vertical bitewings or for children and adults who struggle to tolerate intraoral radiographs, in order to enhance diagnostic information and patient experience.

Acknowledgements
The authors would like to thank the LUDH radiographers, Christine Smith, Charlotte Tilley and Gemma Langley, for providing a training update to clinical staff and for their advice and assistance with data collection.

References
1. NHS England and NHS Improvement. Letter to chief executives of all NHS trusts and foundation trusts, CGG Accountable Officers, GP practices and Primary Care Networks, and providers of community health services. 2020. Available at https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/03/urgentnextstepsonnhsresponsetocovid19lettersimon-stevens.pdf (accessed May 2020).
2. Royal College of Surgeons of England. Recommendations for Diagnostic Imaging during COVID-19 pandemic. 2020. Available at https://www.rcseng.ac.uk/dental-faculties/fds/coronavirus/ (accessed May 2020).
3. Gijbels F, De Meyer A M, Bou Sethal C et al. The subjective image quality of direct digital and conventional panoramic radiography. Clin Oral Investig 2000; 4: 162–167.
4. Abdnian M, Razavi S M, Faghhiian R, Samety A A, Faghhiian E. Accuracy of digital bitewing radiography versus different views of digital panoramic radiography for detection of proximal caries. J Dent (Tehran) 2015; 12: 290–297.
5. Royal College of Surgeons of England and Faculty of General Dental Practice (UK). Selection Criteria for Dental Radiography. 1998. Available online at https://www.fgdp.org.uk/guidance-standards/selectioncriteriadental-radiography (accessed May 2020).
6. Issacson K G, Thom A R, Horner K, Whaites E. Orthodontic radiographs: guidelines. 3rd ed. London: British Orthodontic Society, 2008.
7. Department of Health. National Radiological Protection Board – Guidance Notes for Dental Practitioners on the Safe Use of XRay Equipment. 2002. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/337117/misc_pub_DentalGuidanceNotes.pdf (accessed May 2020).
8. Arkarslan Z Z, Akdevelioğlu M, Güngör K, Erten H. A comparison of the diagnostic accuracy of bitewing, periapical, unfiltered and filtered digital panoramic images for approximal caries detection in posterior teeth. Dentomaxillofac Radiol 2008; 37: 458–463.
9. Kamburoglu K, Kolozlu E, Murat S, Yüksel S, Özgen T. Proximal caries detection accuracy using intraoral bitewing radiography, extraoral bitewing radiography and panoramic radiography. Dentomaxillofac Radiol 2012; 41: 450–459.
10. Terry G L, Noujaim M, Langlais R P, Moore W S, Prihoda T J. A clinical comparison of extraoral panoramic and intraoral radiographic modalities for detecting proximal caries and visualizing open posterior interproximal contacts. Dentomaxillofac Radiol 2016; DOI: 10.1259/dmfr.20150159.
11. AbuEl-Ela W H, Farid M M, Mostafa M S ED. Intraoral versus extraoral bitewing radiography in detection of enamel proximal caries: an ex vivo study. Dentomaxillofac Radiol 2016; DOI: 10.1259/dmfr.20150326.
12. Chan M, Dadad T, Langlais R, Russell D, Ahmad M. Accuracy of extraoral bite-wing radiography in detecting proximal caries and crestal bone loss. J Am Dent Assoc 2018; 149: 51–58.
13. Sabarudin A, Taw Y I. Image quality assessment in panoramic dental radiography: a comparative study between conventional and digital systems. Quant Imaging Med Surg 2013; 3: 43–48.
14. Bakshi B G, Alpoz E, Solgur E, Mert A. Perception of anatomical structures in digitally filtered and conventional panoramic radiographs: a clinical evaluation. Dentomaxillofac Radiol 2010; 39: 424–430.
15. Fujita M, Kodera Y, Ogawa M et al. Digital image processing of dentomaxillofacial radiographs. Oral Surg Oral Med Oral Pathol Oral Radiol 1987; 64: 485–493.
16. Kaepple G, Dietz K, Reinert S. The effect of dose reduction on the detection of anatomical structures on panoramic radiographs. Dentomaxillofac Radiol 2006; 35: 271–277.
17. Lehmann T M, Troeltshs E, Spitzer K. Image processing and enhancement provided by commercial dental software programmes. Dentomaxillofac Radiol 2002; 32: 262–272.
18. Yalinkaya S, Künnel A, Willers R, Thomas M, Becker J. Subjective image quality of digitally filtered radiographs acquired by the Duri Vistascan system compared with conventional radiographs. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006; 101: 643–651.
19. Harvey S, Ball F, Brown J, Thomas B. ‘Non-standard’ panoramic programmes and the unusual artefacts they produce. Br Dent J 2013; 214: 268–262.
20. Public Health England. Dose to patients from dental radiographic Xray imaging procedures in the UK. 2017. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/817972/2019_dental_NDRL_report.pdf (accessed May 2020).
21. Lecomber A R, Faulkner K. Dose reduction in panoramic radiography. Dentomaxillofac Radiol 1993; 22: 69–73.
22. College of General Dentistry and Faculty of General Dental Practice (UK). Implications of COVID-19 for the safe management of general dental practice. A practical guide. 2020. Available at https://www.fgdp.org.uk/sites/fgdp.org.uk/files/editors/Implications%20of%20COVID-19%20for%20safe%20management%20of%20general%20dental%20practice%20guide.pdf (accessed June 2020).
23. Hurley S. Why re-invent the wheel if you’ve run out of road? Br Dent J 2020; 228: 755–756.