Taking a bite out of imaging – modern trends in dental radiography

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According to the most recent Adult Dental Health Survey, 9% of adults with their own teeth reported pain and required dental intervention. Dental radiography plays a crucial part in patient assessment. In the United Kingdom, approximately 21 million radiographs are taken in primary dental care every year.

Commonly taken views (described below) are the periapical (figure 1), bitewing and dental panoramic radiographs.

This article aims to review the basic techniques used in general dental practice, together with recent developments.

Cancer claims and the press

Some recent published epidemiological studies which reached the tabloid press claim links between dental radiography and certain cancers, specifically of the thyroid and meningioma. These studies obviously raise concerns about the use of ionising radiation in dental practice, and cause apprehension within the general population.

However, closer evaluation of these papers would indicate that the results are not as simple as first implied. In particular, they are both based on the participant’s memory and recall of having dental radiographs taken, including those below the age of ten. In addition, the paper suggesting links with meningioma showed significant effects with a single bitewing, but not with a full mouth series, despite the latter giving up to 15 times the amount of radiation. While the studies suggest reducing radiation exposure is true (and obvious), the flaws and issues regarding the study designs are too hard to ignore.4 Since the dental radiography reported in these papers has progressed in terms of radiation safety, dose and selection criteria, the aim of this paper is to review some of these changes and developments.

Overview of current imaging used in general dental practice

Periapical radiographs

Periapical radiographs demonstrate the apices of the roots of individual teeth.

Bitewings

Bitewing radiography is used in the assessment of the crowns of the teeth for caries (decay).

Occlusal radiographs

These views are taken of the upper or lower arches to give a ‘plan’ view of the teeth and jaws. These films are less likely to be taken in general dental practice.

Dental panoramic radiographs (DPRs)

Most institutions know these views by a trade name ‘OPG’, derived from the Siemens Orthopantomograph®. They are predominantly used for a general assessment of the alveolar bone and full dentition, for instance in the case of a neglected mouth, for the assessment of bony lesions/fractures of the mandible and in the assessment of the wisdom teeth prior to extraction.

As with all radiography, good technique (and in the case of plain film, processing) is essential in obtaining a useable image, and unfortunately quality has often been a problem, particularly with panoramic radiographs.

Keeping doses low

Although the doses in dental radiography are much lower than other general radiographic techniques, keeping dose as low as reasonably practicable (ALARP) should still be borne in mind.

Dose reduction is one of the main reasons why many dental practitioners are converting from conventional film-based digital imaging systems.

Digital dental systems currently available fall into two categories:

- Direct systems based on CCD or CMOS receptors:
- Indirect systems based on phosphor plates.

It is largely a matter of personal preference as to which system a dentist would install (figure 2), as both have advantages and disadvantages. These are largely based on the limited range of size and bulkiness of the direct systems, whereas the phosphor plate (indirect) system does require scanning before image viewing. However, indirect systems do cover a larger range of receptor sizes.

Both these digital systems result in a considerable reduction of dose between 60-80% compared to conventional film. They also remove the need for hazardous chemicals for processing and also their waste disposal.

As with all radiography, the selection criteria for the most appropriate imaging is essential. In dental radiography, this was developed through the Faculty of General Dental Practitioners (FGDP), which produced a set of guidelines based on best evidence at the time, the most current edition being published in 2004.4 This document is due for imminent renewal. These guidelines are identical to those recommended in Europe and advise on the appropriate radiographs needed for any given clinical situation.

In essence, the doses of radiation used in dental practice are now considerably lower than in the 1970s and 1980s. Rectangular collimation limiting beam size has also contributed considerably to dose reduction, and we can reassure the general public of the considerable measures taken in dentistry to reduce risk.

All dental practitioners are required under the General Dental Council regulations to obtain mandatory training in dental radiology (currently five hours for every five year CPD cycle). This is to ensure that ionising radiation is used in the most efficient and safe manner.

Cone beam CT

With the advent of dental implants, the requirement for cross-sectional imaging became necessary in order to avoid damage to fragile anatomical structures and to allow accurate measurements for implant placement.

Imaging modalities available in dental practice only provide limited information necessary for this purpose with the result that practitioners were having to utilise conventional CT in collaboration with hospital radiology departments. These scans provide useful information but access could occasionally be problematic and conventional CT is also by
nature a high dose modality and in the oral cavity can be affected by streak artefact from metallic dental restorations.

In view of these problems, there was a need for an imaging modality designed for purpose.

Cone beam computed tomography (CBCT) technology has been present for over two decades, but in recent years CBCT has found its place in dental and maxillofacial practice. A variety of manufacturers have produced machines specifically targeted for high street dental practice, in particular those specialising in implants and orthodontics. As an imaging modality, it has been shown to be a valuable asset in head and neck imaging.

CBCT is different to conventional CT in the way in which it acquires data. Conventional CT uses a fan-shaped x-ray beam, rotating around a patient lying either supine or prone. CBCT works through delivering the radiation as a cone-shaped beam, rotating around the patient in a similar fashion to a dental panoramic machine. The scan time is rapid, where only one revolution of the tube is required to acquire the data in between 10 to 40 seconds. The series of ‘basis’ images, which are similar to a series of offset lateral cephalometric (skull) images, forms the projection data. Complex algorithms, including filtered back projection, are applied to the data to provide primary reconstruction images in three orthogonal planes.

Effective dose does vary depending on the manufacturer, where CBCT effective doses are between 0.035 and 0.10mSv, whereas a typical effective dose for CT facial bones is 0.40mSv.

The clinical application of the modality is broad, where potential maxillofacial uses include:
- Evaluation of dental and maxillofacial trauma;
- Assessment of bone pathology;
- Establishing the relationship of the inferior alveolar nerve and lower third molars for pre-surgical assessment (figure 3);
- Alveolar bone assessment during pre-surgical implant planning;
- Investigation of the maxillary, paranasal, ethmoid and frontal sinuses.

CBCT is particularly good at evaluating bone and the dental hard tissues, and produces less streak artefact than conventional CT, which means it is more usable when large dental restorations are present. Quality images are very dependent on the patient keeping still during acquisition, which can limit its use in very young children or patients with movement disorders.

A disadvantage of the modality is that anatomical structures not normally seen in conventional dental radiography are being imaged with CBCT, such as base of skull and middle ear. This leads to a potential for missing pathology in these areas. In addition, the guidelines failed to mention CBCT. In many regards, dental cone beam technology has been developing at a faster rate than its evidence based usage, with a tendency in some countries for it to be used when more conventional methods would provide similar and more dose-effective information.

These problems were addressed by a group set up under the European Commission (SEDEXTExCT). This group had the remit of evaluating the role of CBCT in dental practice, and in assessing the training requirements for its safe usage, including radiation protection. Their work culminated with a publication in 2011 of the first clinical guidelines.

In addition, they are developing online training for users of the modality.

In addition to the work of groups such as SEDENTExCT, manufacturers have developed units with a smaller field of view, which are less likely to demonstrate anatomy outside the dentists’ usual remit. Many of these units are now components of ‘hybrid’ DPR units.

**Conclusion**

Dental radiography is often regarded as the Cinderella subject of radiography. However, significant developments over the past 20 years have ensured it continues to develop as an effective and safe modality, providing images with minimal dose.

**References**

5. SEDENTExCT consortium. Radiation Protection: Cone Beam CT for dental and maxillofacial radiology 2011.

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**TABLE 1**

Typical doses for various radiographic examinations. Data from several sources.

<table>
<thead>
<tr>
<th>Examination</th>
<th>Dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT head</td>
<td>2</td>
</tr>
<tr>
<td>Cone beam CT</td>
<td>0.1</td>
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<tr>
<td>PA chest</td>
<td>0.015</td>
</tr>
<tr>
<td>Dental panoramic radiograph</td>
<td>0.010</td>
</tr>
<tr>
<td>Intra-oral image (x1)</td>
<td>0.002</td>
</tr>
</tbody>
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**FIGURE 1**

Patient about to undergo a periapical radiograph. Note the film holder, allowing accurate and reproducible alignment. The use of such holders is now regarded as routine practice.
FIGURE 2
Comparison of the three types of intra-oral receptor. Direct system (right), phosphor plate (centre), film (left).

FIGURE 3
A typical multiplanar reconstruction of a CBCT image showing its value in determining anatomy. In this case, the position of the lower right third molar to the inferior dental canal.