VERIFIABLE CPD PAPER

'Non-standard' panoramic programmes and the unusual artefacts they produce

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In brief

Suggests non-standard artefacts are not widely discussed which may lead to practitioners becoming unsure about them when they arise.

Describes two clinical cases and the technical explanation for these artefacts.

Provides learning points to improve the readers' clinical practice.

Dental panoramic radiographs (DPTs) are commonly taken in dental practice in the UK with the number estimated to be 2.7 million per annum. They are used to diagnose caries, periodontal disease, trauma, pathology in the jaws, supernumerary teeth and for orthodontic assessment. Panoramic radiographs are not simple projections but involve a moving X-ray source and detector plate. Ideally only the objects in the focal trough are displayed. This is achieved with a tomographic movement and one or more centre(s) of rotation. One advantage of digital radiography is hardware and software changes to optimise the image. This has led to increasingly complex manufacturer specific digital panoramic programmes. Panoramic radiographs suffer from ghost artefacts which can limit the effectiveness and make interpretation difficult. Conversely 'conventional dental imaging' such as intraoral bitewings do not suffer the same problems. There are also now several 'non-standard' panoramic programmes which aim to optimise the image for different clinical scenarios. These include 'improved interproximality', 'improved orthogonality' and 'panoramic bitewing mode'.This technical report shows that these 'non-standard' panoramic programmes can produce potentially confusing ghost artefacts, of which the practitioner may not be aware.

Background

Dental panoramic radiographs (DPTs) are commonly taken in dental practice in the UK with the number estimated to be 2.7 million per annum.[1] They are used to diagnose caries, periodontal disease, trauma, pathology in the jaws, supernumerary teeth and for orthodontic assessment. The dose from a panoramic radiograph is in the region of 25 microsieverts.[2] This can be reduced by collimating to sectional areas or 'dentition only' collimation which removes the condyles and parotid salivary glands. Dental radiography has benefited from a reduction in doses to patients due to, in part, the introduction of digital imaging. Panoramic radiography conversely has not seen such a decrease.[3] This is because the (dose decreasing) intensifying screen present in film-based panoramic radiography is removed for digital panoramic radiography.

Panoramic radiographs are not simple projections but involve a moving X-ray source and detector plate. Ideally, only the objects in the focal trough are displayed. This is achieved with a tomographic movement and one or more centre(s) of rotation. Panoramic radiographs suffer from ghost artefacts which can limit the effectiveness and make interpretation difficult. Conversely, 'conventional dental imaging' such as intraoral bitewings do not suffer the same problems. The most common ghost artefacts are diagrammatically represented in Figure 1b, with colourised anatomy and ghost shadows seen on Figures 1c and 1d respectively.

Ghost artefacts have also been described by some as 'ghost shadows' or 'artefactual shadows'. They manifest when objects outside the focal trough are still included in the image projected over the anatomy in the focal trough. The most noticeable artefacts arise from the opposite angle of the mandible, the hyoid, cervical spine (C-spine) and the hard palate. Due to the eight degree upward angulation of the X-ray beam the ghost artefacts appear higher than the true anatomy and because these structures are outside the focal trough the ghosts appear blurred.

One benefit of digital radiography is the ability to introduce hardware and software to improve image quality. This has led to increasingly complex manufacturer specific programmes. The exact hardware and software changes are often released in brief but not in detail. In this technical report the authors show two case reports followed by an experiment and explanation to show where 'non-standard' panoramic programmes have produced potentially confusing ghost artefacts, of which the practitioner may not be aware.

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Refereed Paper. Accepted 5 July 2017
DOI: 10.1038/sj.bdj.2017.707

Official journal of the British Dental Association.

Case report 1

A child undergoing orthodontic assessment was seen in clinic and after examination was sent for a full DPT and lateral cephalometric radiographs. The DPT was taken on a ProMax (Planmeca, Helsinki) using P2000 (improved orthogonality) programme. Reviewing the panoramic radiograph, the orthodontist noticed two supplemental/supernumerary teeth in the upper right quadrant (URQ). They subsequently requested a small volume cone beam computed tomography (CBCT) scan to evaluate the anatomical relations and pathology in greater detail (Fig. 2).

On receiving the CBCT request during protocoling, the consultant dental and maxillofacial radiologist reviewed other imaging.

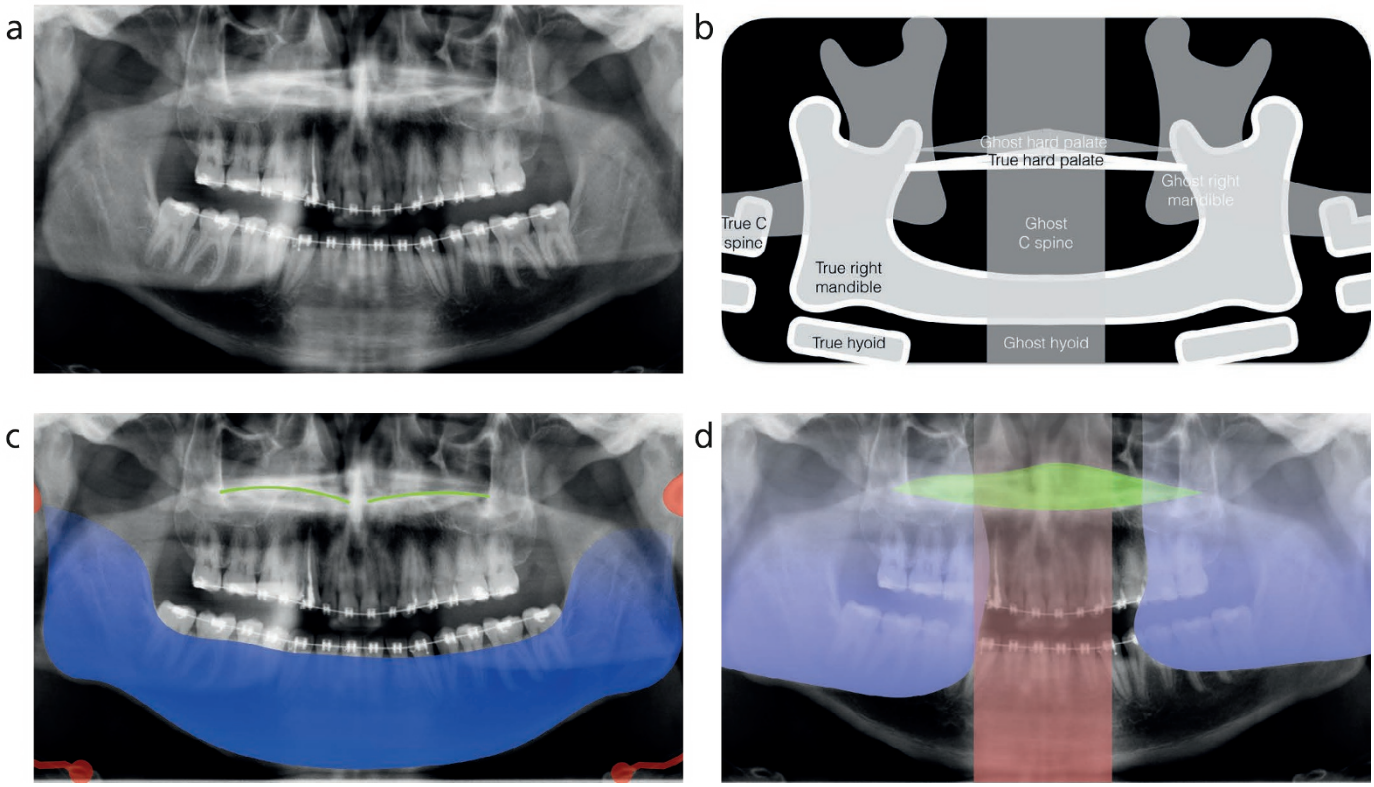

Fig. 1 Ghost artefacts on panoramics. a. Unaltered panoramic radiograph; b. Diagrammatic representation of anatomy and ghosts; c. Panoramic with colourised anatomy; d. Panoramic with colourised ghosts; Blue = mandible, Green = hard palate, Red = C-spine and hyoid

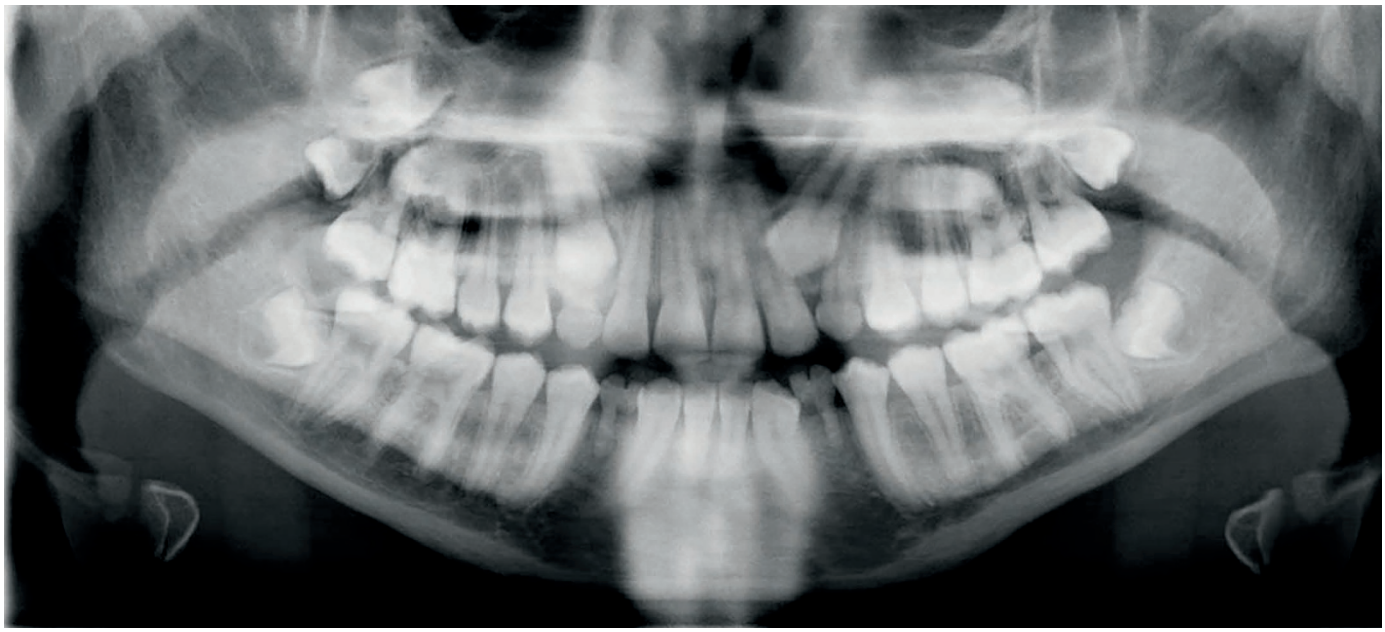

Fig. 2 DPT with what appears to be supplemental/supernumerary teeth in URQ

Fig. 3 Lateral cephalometric radiograph – note no supernumerary/supplemental teeth in URQ

The lateral cephalometric radiograph showed no evidence of a supernumerary (Fig 3). On further investigation the data attached to the panoramic image revealed it was taken with a 'non-standard' panoramic programme (in this case P2000 improved orthogonality). The clinician was informed of the ghost artefact on the DPT, there were no supernumeraries and the CBCT was not taken.

Case report 2

The patient came in for a special care assessment and after clinical examination was sent for a panoramic radiograph to assess the dentition. On review, there was a discrepancy with the charted teeth (Figs 4 and 5).

In the initial panoramic radiograph the positioning is substandard; the patient is rotated in the scanner and there is a large air shadow in the oral cavity. The radiograph was deemed of insufficient quality by the clinician and a repeat was requested. The repeat was done using a standard panoramic programme (Fig. 6).

In this second DPT the lower left posterior region is seen as edentulous. In the first panoramic (taken with a 'non-standard' programme) there is a ghost artefact of lower right second molar (47) which mimics a tooth in the lower left quadrant.

Ghost artefacts

As discussed, ghost artefacts on panoramic radiographs 'traditionally' appear on the opposite side, higher and out of focus. The following case shows a standard panoramic radiograph of a dry mandible with a household screw affixed to the lingual aspect in the right angle (Fig. 7).

The ghost of the lingually placed screw appears on the opposite side, higher, out of focus and pointing the same direction.

In the case reports shown above, the extra teeth seen (in URQ in case 1 and LLQ in case 2) do not appear as 'traditional' ghosts would. This is because they have been mirrored, appear in focus and at broadly the same height.

The panoramic radiographs in these case reports were taken using an 'improved orthogonality' programme which aims to improve the appearance of the alveolar crest, particularly for periodontal or implant applications. Unfortunately, it also has the unwanted and potentially unknown effects of mirroring the ghosts and keeping them in relatively good focus (Fig. 8).

The tomographic movement of the panoramic machine relies on the principle of the X-ray source and detector plate moving in opposite directions around the patient. This is key in blurring out unwanted anatomy which lies outside the focal trough. In the improved orthogonality programme the machine 'strafes' in the molar/premolar region to a degree – the source and detector move in the same direction. This has the effect of becoming much more like a lateral projection, therefore the anatomy is neither reversed nor defocused as strongly (Figs 9 a and b).

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Fig. 5 Chart notes

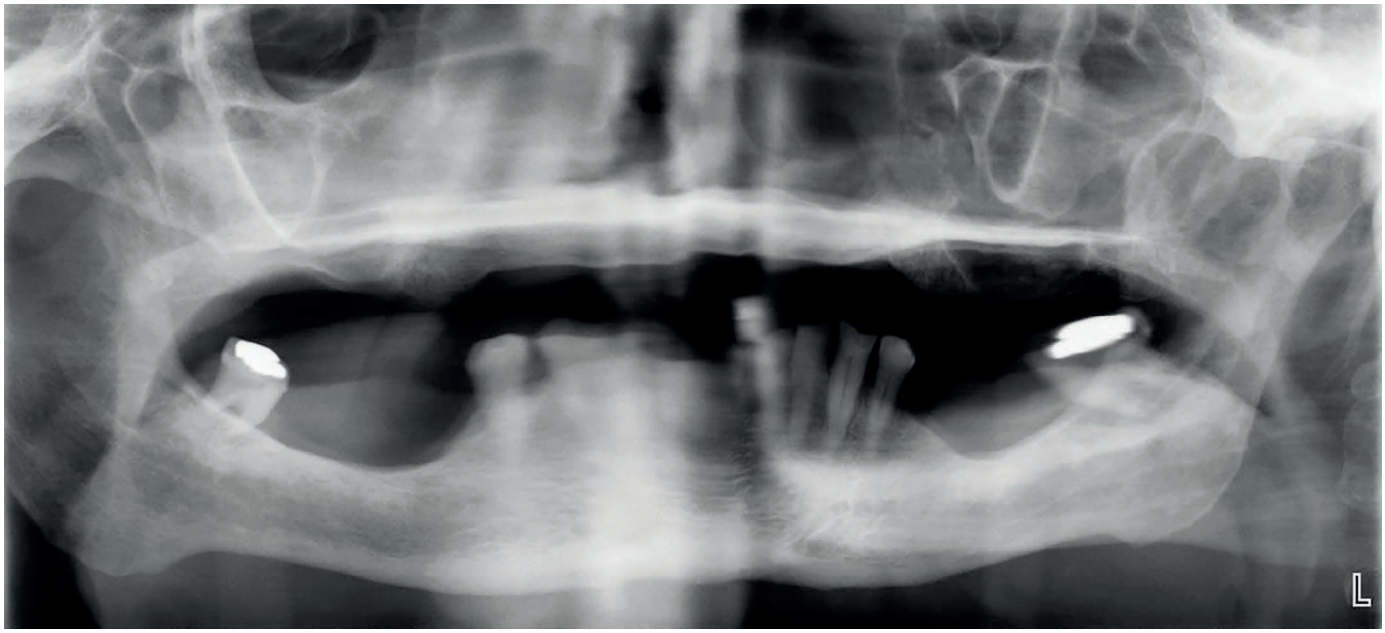

Fig. 4 DPT – note the molar in the LLQ

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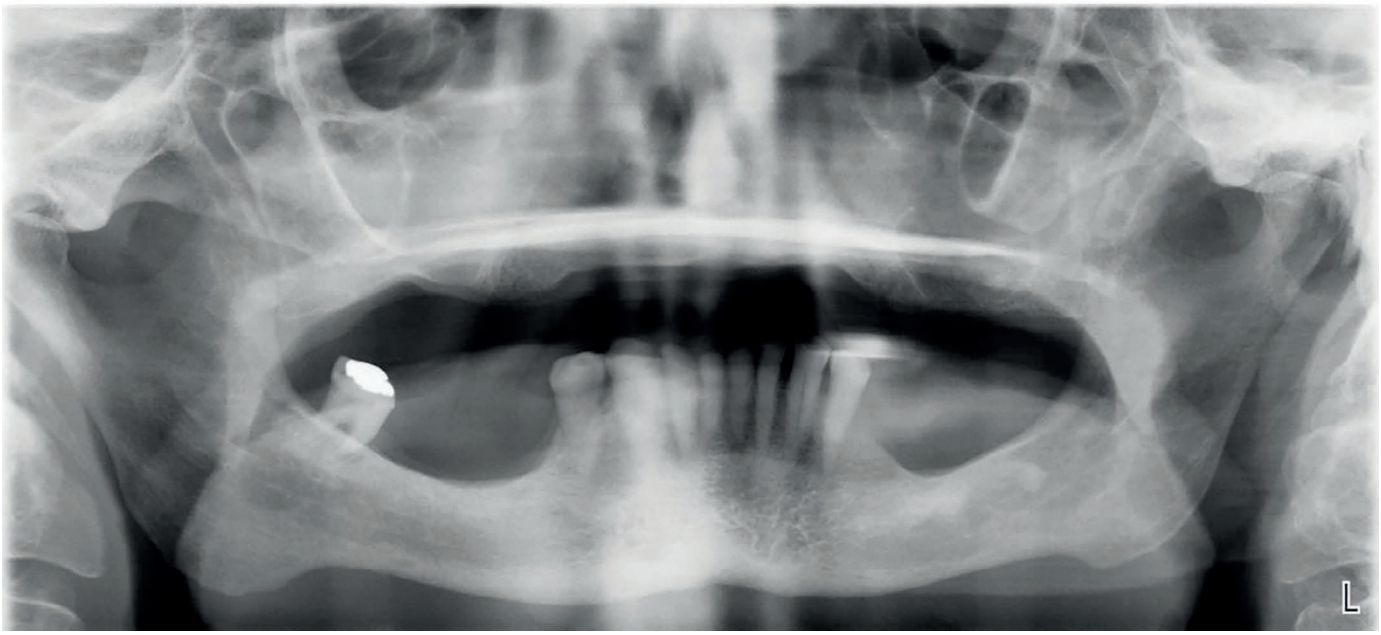

Fig. 6 DPT on regular programme – the radiograph now corresponds to the chart

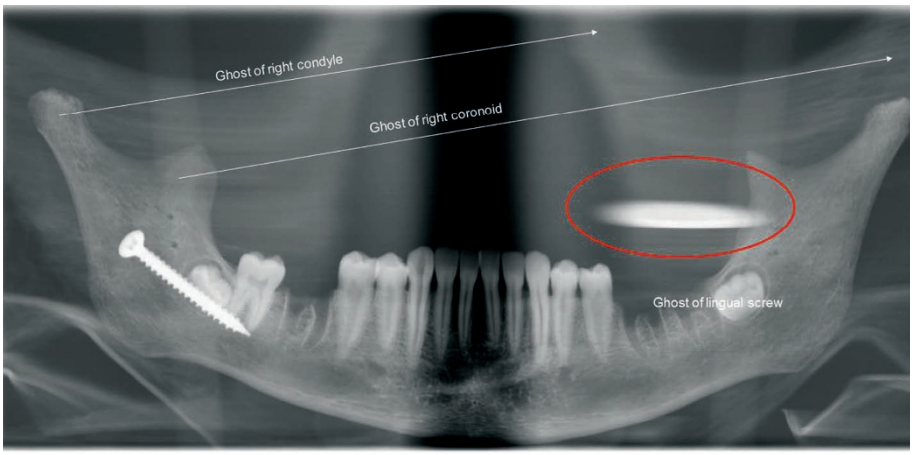

Fig. 7 Regular ghost seen in a dry mandible

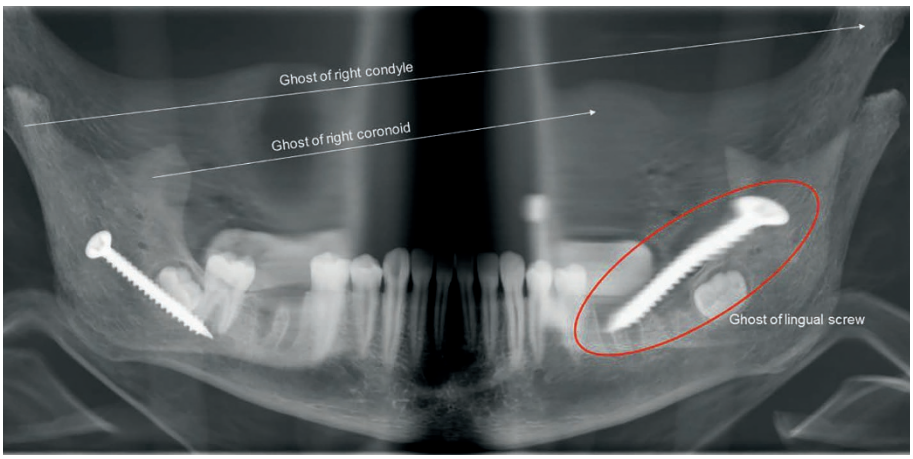

Fig. 8 The same mandible in the same position as Figure 7 however the 'improved orthoganality' programme has been selected.

Discussion

In both the clinical cases the ghosts caused by the 'improved orthogonality' programme tricked the clinicians. In the first case it nearly resulted in an unnecessary CBCT examination of a child. Fortunately, this artefact was recognised at protocoling stage and the examination was cancelled. This highlights the benefit of reviewing all previous relevant imaging.

Some of the programmes available to use on digital panoramic machines aim on producing superior images but their use should be considered carefully. It may be pragmatic to label the radiograph 'non-standard programme' so other clinicians who may view it are aware.

Some authors have indicated 'panoramic bitewing' modes are a real alternative to intraoral periapicals,[4] however, these programmes can also suffer the same artefacts (Fig. 10).

One limited study has shown panoramic radiography to be as or more effective than intraoral bitewing radiographs in spotting caries. Panoramic radiography, however, has more inter proximal overlap,[6] lower spatial resolution and generally higher dose compared to well taken intraoral images. The vast majority of scientific evidence[7,8] and selection criteria[9] point towards intraoral bitewings being favoured for caries detection. The panoramic bitewing mode may, however, be useful in patients who will not tolerate

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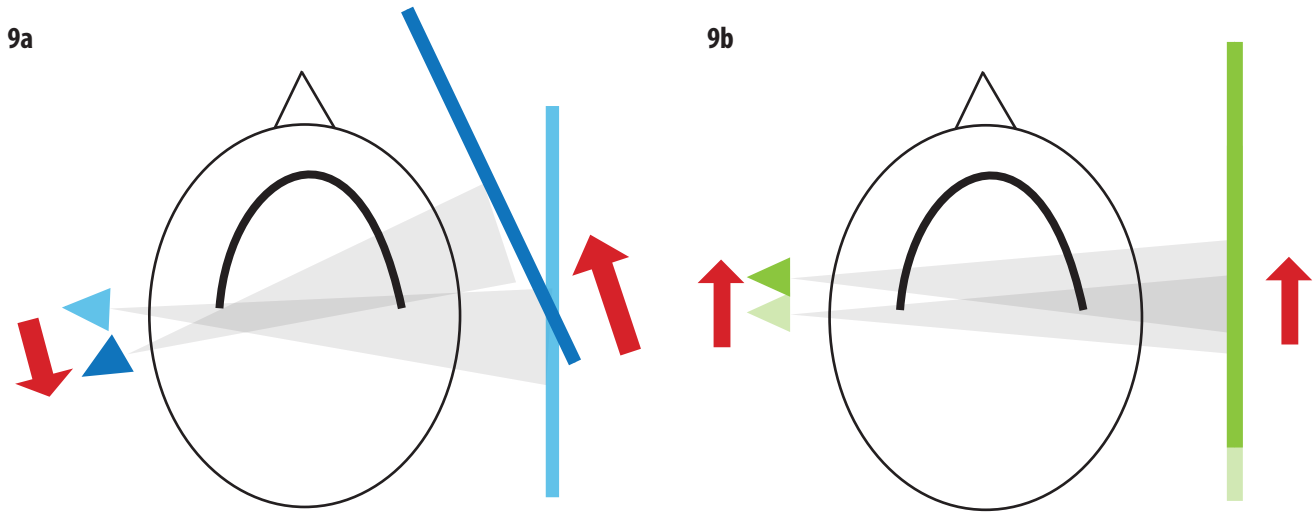

Fig. 9a and 9b Diagrammatic representation of the panoramic machine movement in standard mode (9a) and 'improved orthogonality' (9b)

intraoral radiographs; with an understanding the limitations.

The artefacts here are not unique to one manufacturer, suggesting the technology is widely adopted and included. Other brands may offer similar technology under different names.

Learning points

- Panoramic radiographs are very sensitive to patient positioning and extra care should be taken to ensure the patient is set up correctly
- You should always review prior imaging before taking new radiographs. This is required by UK law (IRMER 2000) and you should be aware of any legislation in your country of practice. In the first case report, had the lateral cephalometric radiograph not been reviewed it is likely the CBCT would have been taken, resultingw in an unnecessary radiographic exposure of a child
- Operators should be familiar with the settings on their digital panoramic machines and aware of the potential for unusual ghost artefacts. If in doubt as to the functioning of your machine, consult the manufacturer
- Finally, if you cannot explain the appearance you see on a panoramic, consider referral to your local dental and maxillofacial radiology department for a specialist opinion.

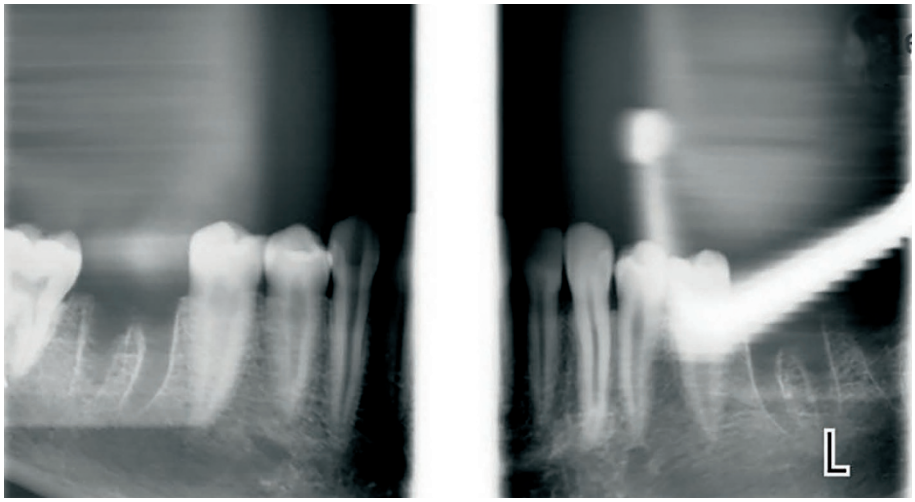

Fig. 10 Bitewing programme of the same dry mandible in Figures 7 and 8

With thanks to E Whaites, M Payne and J Harvey for proof reading

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