DIGITAL IMAGING

Recognise the importance of quality assurance

There are two types of digital image receptor both of which capture a two dimensional image of the three dimensional patient. These are Computed Radiography (CR)

• Photostimulable phosphor plates (PSPs)
• Direct Digital Radiography (DR) solid-state detectors (SSDs).

There are approximately 256 shades of grey pixels which together make up the finished digital image. The sensors are very sensitive to x-rays and so the exposure to the patient can sometimes be dramatically reduced in relation to that which was used with conventional radiographic emulsion film.

PHOTOSTIMULABLE PHOSPHOR PLATES (PSPS)

Under a protection layer is a photo sensitive phosphor plate. This layer absorbs and stores the X-ray energy. After exposure the plate is placed in a processor where it is scanned and the energy is released as light. The light is detected by a photo multiplier and the image is divided into pixels. A
photomultiplier gives them a numerical value in relation to the intensity of the light released

The digital information is stored in the computer. The image can then be manipulated and displayed. PSPs are comparable in size to a conventional x-ray film and are compatible with most film holders. The more radiation that hits the sensor the darker the image will be. The capturing of the image is not instant but it takes only a matter of seconds rather than the few minutes it takes to process an emulsion film. After the plate has been scanned the latent (invisible) image is then cleared by being exposed to light, either in the scanner or less often nowadays manually on a light box.

QUALITY ASSURANCE FOR PSPS

SURFACE MARKING

The phosphor layer is delicate and very easily marked by any form of rough handling. All staff handling PSPs should be aware that they must not bend or scratch them since even normal handling can damage the surface. This marking can degrade the image significantly and is irreversible for any future image production.

If the scanning system does not have an integral white light clearer then the plates should be placed on an X-ray viewing box to erase the latent image. Problems can occur when the plate is lifted off after clearing. If the plate is slid across the
surface of the box the plate can be scratched. To minimise the possibility of this occurring the box can be covered with cling film or see through bubble wrap allowing the plate to be lifted off rather than slid across the surface. Custom made mats are available that resemble a rubber bubble wrap on which the plate can be placed prior to and after scanning allowing the plate to be lifted off any work surface without scratching.

To ensure that PSPs are not marked beyond what is acceptable for image reading, the serial number should be taken and regular checks should be done to monitor for marks.

To do this the plate should be placed on a surface in its protective packet. No step wedge should be used. Next, the spacer cone should be lined up with the plate at a distance of 20 cm (the usual focal skin distance used in paralleling technique). The exposure given is very small (tiny flash exposure) and when scanned any marks will be visible.

Each surgery should be responsible for its own plates. The time frame between these checks will vary in relation to the number of images captured and the quality of sensor handling by the staff.

**FOGGING LIMITATION**

As the PSPs are very sensitive to radiation, even background radiation can base fog them. To limit this, the plate should be cleared every day by placing on a light box for a few minutes
before use. If this is done in the morning the plate should be fine until the end of the working day. Once again, to avoid marking, cling film can be stretched over the viewing box or see through bubble wrap placed on the box before placing the sensors, blue side down, on the surface to clear. Alternatively, if the scanner has an integral light clearer the sensors can be cleared first thing every morning in the scanner.

**SENSOR POSITIONING**

Problems can occur in relation to the image receptor not being firmly held by the bite blocks in paralleling technique holders, if the same bite blocks are used with the phosphor plates that were being used with x-ray film. An x-ray film packet is much thicker than a phosphor plate; it has black paper around it, lead foil behind it and a thick waterproof cover. The phosphor plate is usually the only item in the waterproof packet and is consequently much thinner. The difference in thickness of the sensor in the bite block compared to a film packet makes accurate positioning in the mouth very difficult as the plate tends to slip off the holder. To avoid this happening, thicken the phosphor cover with a white cardboard bitewing tab. This tab also doubles as a “target” when checking the position of the sensor in the mouth before aligning with the spacer cone. The sensor now stays securely in the holder. This cardboard tab also
protects the plate at the point where it is placed in the bite block and where it can easily be damaged.

**ENDODONTIC X-RAY HOLDERS**

Due to the lack of back support on the endodontic holder many image receptors bend in the roof of the mouth and the apex of the root is missed or elongated. The image receptor also often moves in the holder making accurate imaging difficult. Use two folded bitewing tabs to stiffen the waterproof packet and also ensure that the image receptor is held securely during positioning.

**AMBIENT LIGHT IMAGE REMOVAL ENSURING THE IMAGE STAYS CAPTURED.**

Are your right and left bite wings the same shades of grey?

After image acquisition, the plates should be protected from ambient light image removal. The exposed plates should not be left, even for a few minutes, unprotected from light even when in a waterproof packet. Ideally, when taking the images, the room blinds should be closed and the lights dimmed and light boxes switched off.

As the image is cleared in the scanner by light the plate should be kept as dark as possible when image capturing and when
being transferred to the scanner. To ensure this the exposed plate should be kept in a light tight box prior to scanning. The scanner should be positioned in a dim room away from bright lights to enable plates to be loaded without losing image quality.

Special black boxes can be purchased that allow the plate to be posted in the top like a money box. Light cannot get in and the latent image will be safe until it is transported to the scanner. Alternatively a dental appliance box or similar could be used. These are small, light tight, easy to clean, non expensive and possibly already in the practice!

**EXPOSURE SETTINGS**

Guidance should be sought from a medical physicist to ensure that exposure settings are adjusted when a practice moves to a digital system.

PSPs have wide exposure latitude, which means they can give similar results when using a number of different exposures, unlike emulsion films which will be light or dark in relation to the exposure.

A number of test images can be taken using step wedges or extracted teeth to ascertain the lowest exposure that gives an acceptable enhanced image. This becomes the maximum exposure.
Other problems that can be encountered are with images that lack contrast and have an overall grey appearance (greying out). These are not images that can be enhanced by the computer to give more contrast. It is possible that the exposure is too low.

If changes of exposure are being considered to give better quality images then guidance once again should be sought from your medical physicist.

**ARTEFACTS THAT MIMIC PATHOLOGY. UNSHARP MASK SUBTRACTION (UMS)**

Many of the image acquisition processes on digital systems are out with the control of the user. These are intended to improve the image but sometimes artefacts that mimic pathology can result. Areas where there are high intensities, like the base of a restoration or around dense bone, can result in a dark halo effect which can look like pathology. This is called “rebound artefact”. During processing and prior to viewing on the monitor part of the acquisition process takes a blurred version of the image and subtracts it from the original. The blurred image is wider than the original and so when subtracted it can cause a shadow effect. Image processing artefacts are becoming more subtle with more sophisticated systems. To minimise potential misdiagnosis it might be prudent to consider other areas unrelated to the area in question and consider if the halo effect is present.
VIEWING CONDITIONS

Many dental surgeries are bright well lit rooms. This can cause problems when reading images on computer monitors. It is important to ensure that optimum viewing conditions are obtained to allow accurate assessment of the computerised image. The monitor should be placed in a dimly lit area where the light levels are approximately equal to that which would be normal in an overcast day or darker. A light level of about 50 to 100 lux, the SI unit luminescence, would be acceptable. Many surgeries are lit to a level of 300 to 500 lux which is too bright for optimum viewing conditions. The solution is to move the monitor or place a hood around it to cut down on light pollution.

MONITORS

Test patterns that can be used to check monitor condition can be downloaded from the web:
Society of Motion Pictures and Television Engineers (SMPTE) Technical Group 18 QC (TG18-QC)

These images should be captured and archived to be displayed at regular intervals possibly monthly. These test the overall operation of the system and should be viewed in the same light conditions used in the surgery when viewing digital images. These images should be viewed full-screen for all tests.
Whichever test pattern is used the monitor should be checked for

- brightness,
- contrast,
- resolution and
- geometric distortion.

There are two squares on the test pattern one black and one white which are marked 5% detail on the 0% square (black) and 95% detail on the 100% square (white). Both of these should be distinctly visible and if not the monitor settings should be adjusted until they become so. Most monitors cope better with the 95/100% than the 0/5% but if the ambient light is kept low then both should be clearly visible.

**DIRECT SENSORS**

**SOLID STATE SENSORS CCD and CMOS**

SSDs contain solid state materials such as amorphous silicon or amorphous selenium in their construction. There are two types of detectors containing either

- a charge coupled device (CCD)
- or a complementary metal oxide semiconductor (CMOS).

The intra-oral systems generally have a flexible cable connecting the detector directly to the PC. Images are collected
in real time and can be viewed on the monitor. The sensors are bulky and rigid and compromised patients, children and elderly will probably not deal well with SSDs.

In comparison to conventional film or PSPs the imaging area is smaller and as a result approximately three less points of interest will be captured by the Direct Digital Sensor. Consequently accurate positioning is essential to cover the area of interest. The presence of the cable will not allow the teeth to be in occlusion during the taking of bite wing radiographs. A consequence of overexposure could be pixel overload "blooming" which can result in black banding on the image.

**Further reading**

- Greenall C, Drage N, Ager M. Quality Assurance Tests for Digital Radiography in General Dental Practice. Dent Update 2014; **41**: 126-134