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ORIGINAL ARTICLE

Work flow with digital intraoral radiography: A systematic review

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Abstract

Objective. This systematic review evaluates the six most frequently emphasized advantages of working with digital radiography: less working time, lower radiation dose to the patient, fewer retakes and errors, wider dynamic range, easier access to patient information and easier image storage and communication. Moreover, some clinical aspects and possible disadvantages of digital imaging that were not foreseen at the beginning of the digital era, such as patient discomfort, damage to the receptor, degradation of the image, cross-contamination and viewing conditions, were assessed. ***Material and methods.*** The literature search used the PubMed database with no limits and was performed during June to August 2009. Search strategies are described in the text for each of the mentioned tasks. A hand search of task-specific journals supplemented the search strategies. ***Results.*** Time seems to be saved when switching from film to digital imaging in dental practice, a dose reduction may not be obtained, retakes and errors may be increased, the dynamic range may be wider with photostimulable storage phosphor (PSP) plates but not with sensors, the effect on patient information has not been well studied and storage and communication create new challenges with regard to handling large files and image compression. In addition, patient discomfort seems to be pronounced with sensors compared with PSP plates and film, the PSP plate may be scratched in clinical use and a two-layer barrier seems to be needed to prevent contamination of the receptor. The type of monitor may not be of major concern if the image is viewed in a room with subdued light. ***Conclusions.*** Not all of the predicted advantages with digital compared to film-based radiography hold true in daily clinical work. Of particular interest is the relationship between number of images, retakes and the dose given to the patient.

Key Words: *Digital radiography, review*

Introduction

Intraoral radiography is, despite the development of new advanced methods, still the most commonly used radiographic technique in dental practice. Digital receptors have gained ground in dental practices worldwide. In 2001, 17% of Norwegian dentists worked with a digital receptor [1], and this percentage is increasing in all countries.

The dentist can choose between two basically different types of receptor for digital intraoral radiography: a solid-state sensor with or without a cord [charge-coupled device (CCD) or complementary metal oxide semiconductor (CMOS)] and a photostimulable storage phosphor (PSP) plate. More than two decades have passed since the first solid-state sensor for intraoral use was marketed [2,3]. The CCD sensor consists of chips in an integrated circuit and is built of silicon plates, where electrical gates are placed in a matrix of columns and rows. Silicon crystals convert absorbed radiation to light. The intensity of the light corresponds to the amount of absorbed radiation. When the light reaches the CCD, electrons are emitted from the silicon in proportion to the light intensity and the electrons make up the latent image. The latent image is moved in a whole column or row at a time, hence the name charge-coupled, to a plate in the CCD, where it is integrated, treated and digitized. CCD systems have a cord connecting the sensor to the computer and the image is shown almost instantaneously on the computer monitor after exposure [4].

CMOS sensors are constructed in more or less the same way as CCD sensors. In contrast to the CCD, each gate is read individually in the CMOS. Most CMOS sensors have a wire, but cordless versions have

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been marketed. For cordless sensors the information stored in the chips is transformed into radio waves, which are transmitted to a stationary radio-wave receiver connected to a computer. The distance between the sensor in the patient's mouth and the radio-wave receiver can be up to 3.5 m [5]. CCD and CMOS sensors for intraoral use are available in different sizes. The largest corresponds to the outer dimensions of a 3×4 cm^2 adult film, but the radiosensitive area is 2–3 mm smaller in height and width. The thickness of the sensors varies: the thinnest is ≈ 3 mm, and the thickest is ≈ 7 mm where the cord is attached. Sensor holders with varying flexibility have been developed for the sensors.

The PSP plate has a surface which is ionized when the plate is exposed and a latent image is produced. This latent image is read by a red laser beam in a scanner. The laser light stimulates the 'caught' electrons, whereby energy is emitted in the form of blue light. This is recorded by a photo-multiplier, which turns light into an electronic signal that is digitized [6]. Scanning time is from ≈ 4 s to several minutes depending on the type of scanner and the spatial and contrast resolution of the image. PSP plates come in different sizes (from normal child-film size 22×31 mm^2 to occlusal-film size 57×76 mm^2 for some systems) and can be used with the same holders as film.

The theoretically achievable spatial resolution in digital radiography systems varies between 6 and 26 line pairs/mm [7]. The spatial resolution of digital images can also be expressed as the number of pixels per unit of measurement, and, in general, PSP plate systems generate images with a lower spatial resolution than sensors depending on the make and the reading settings in the scanner.

The contrast resolution or bit depth (number of possible shades of gray that a pixel can achieve) of digital images is between 8 (standard resolution; 256 shades of gray) and 16 (high-resolution; 65,536 shades of gray), where the image file size when stored increases proportionally with the resolution. For PSP plate systems the scanning time is also proportional to the resolution of the image. An early study showed that there was no difference in diagnostic accuracy between digitized images with 6- and 8-bit depth [8]. Recent caries diagnostic studies showed that the accuracy of lesion detection was only influenced to a small degree by the spatial resolution of the image [9–11] or by an increase in bit depth from 8 to 12 or 16 bits within the individual digital system [10]. A study of the accuracy of assessing the position of an endodontic file showed on the other hand that 12-bit images gave more accurate information than 8-bit images [12], and another study showed that a high-resolution sensor was more accurate than a PSP plate system, with lower resolution for diagnosing root fractures [13]. Recently marketed CMOS sensors seem to provide higher spatial resolution than previous CCD sensors; the effect of this has however yet to be evaluated.

In the 1990s, reviews were published stating the possible advantages of digital radiography for dentists [6,14–18], and more recent reviews have focused on the same advantages [19–21]. The six most frequently emphasized advantages were:

(1) Working time from image exposure to image display was predicted to be reduced compared to film imaging.
(2) The dose to the patient was predicted to be reduced since digital receptors should be more sensitive to X-ray radiation than film.
(3) Fewer retakes and errors were predicted since inadequate density and contrast after wet processing are the main reasons behind unacceptable films, and since a digital image may be enhanced to serve several diagnostic purposes.
(4) Dynamic range should be wider than with film, which was predicted to result in fewer retakes.
(5) The information given to the patient should be improved since it should be easier to explain the radiographic information to the patient when the image is seen on a monitor.
(6) Image storage and communication should be easier since the 'original' image is not misplaced or lost when sent to third parties.

Focusing on work flow when using digital receptors for intraoral patient examination, the present review attempts to evaluate what evidence exists in the literature for the claimed advantages. Moreover, some clinical aspects and possible disadvantages of digital imaging not foreseen at the beginning of the digital era, such as patient discomfort, damage to the receptor and degradation of the image, cross-contamination and viewing conditions, are assessed. Studies comparing various digital receptor makes with respect to diagnostic quality are not included in this review.

Working time

One of the major advantages with digital receptors was claimed to be a reduction in working time. A search of PubMed using the words "time AND digital AND intraoral AND radiograph*" resulted in 39 studies, three of which had evaluated time use in original research. Furthermore, three questionnaire studies were found.

In a questionnaire study, general dentists who had switched to a digital receptor reported that they saved approximately half an hour per day in time spent on radiographic procedures [22]. Dental students reported that they saved more time when they used a CCD sensor than when they used a PSP plate system in connection with root canal treatment [23]. Pediatric dentists stated that an image was obtained faster with sensors than with phosphor plates [24].

A study that measured the working time in seconds concluded that the working time for a full-mouth status with phosphor plates was between 27 and 31 min, and there was no difference between the various PSP plate systems [25]. One study found that less time was required when using a wireless sensor than a wired sensor or a film [5]. Another study found that the working time for PSP plate systems, which require erasing of remaining information on a light box subsequent to scanning, may be as little as 5 s under optimal light intensity [26].

In conclusion, even though there are few studies that have actually timed or estimated the working time with a digital receptor compared to film, it seems reasonable to conclude that time is saved when switching from film to digital imaging in dental practice. However, there are no studies that have evaluated the time spent on post-processing and enhancing the digital image before a specific diagnosis is reached. Whether this additional work may reduce the time saved with digital imaging is yet to be seen.

Dose to the patient

One of the claimed advantages of intraoral digital imaging was a reduction in the radiation dose to the patient. A search of PubMed using the words "dose AND digital AND intraoral AND radiograph*" resulted in 27 studies, seven of which were original research on dose. In addition, three questionnaire studies were included.

A decade ago, studies estimated that a dose reduction of 30–60% was obtained with early marketed sensors compared to standard dental film [27,28]. Two recent studies reported that the dose needed for a 'diagnostically acceptable' image was higher for film than for digital receptors [29,30]; one found that it was lower for sensors than phosphor plates [29], while the other found the opposite [30]. A dose reduction was however not obvious when the observers selected their preferred image instead of the 'acceptable' image [29]. Over the last 20 years, film has also increased in sensitivity from D-speed to E-speed and from E-speed + to F-speed film [31], and the difference between the radiation sensitivity for film and digital receptors is smaller. There may still be a dose saving for an exposure with a PSP plate system compared with film [32], and the dose saving for a single exposure with most solid-state sensors seems to be larger than with PSP plate systems [31]. However, a sensor has an active radiation field, which is smaller than for film and plates, resulting in more exposures to cover the same area with a sensor compared to film [28,33]. Even with the largest sensor size, on average two fewer surfaces are displayed on a bite-wing performed with a sensor compared to the same exposure with film or a PSP plate [33].

In questionnaire studies, dentists using sensors stated that they took more periapical radiographs than dentists using PSP plates [34], and dentists were concerned about the increased dose to the patient, which was stated as a possible disadvantage of digital imaging [35]. In a study of U.S. dentists, lower radiation dose was reported as an advantage of digital imaging [36].

In conclusion, it seems that the dose for a single exposure is lower with most digital receptors than with film, but differences between digital receptors and film are smaller with today's receptors due to the increased sensitivity of film. When the factors frequency of retakes (see below), number of images needed to cover a given area and dose for a single exposure are combined, it may be speculated whether a dose reduction is obtained when using digital receptors compared with film. However, no controlled clinical trial has been conducted between a digital receptor and film with the purpose of evaluating this issue. Further, no study seems to have assessed whether dentists working with sensors tailor their tube collimation to the size of the active area of their receptor, or whether other precautions are taken in order to reduce the radiation dose to the patient.

Retakes and errors

It was predicted that when wet processing and chemicals became obsolete, the result would be higher image quality and fewer retakes on average. A search of PubMed using the search criteria "digital intraoral/periapical AND retake/error" resulted in 11 studies, four of which were original research regarding positioning errors with digital receptors. Furthermore, four studies were found by a hand search.

Questionnaire studies involving general practicing dentists showed that dentists working with digital receptors took more images and did more retakes than dentists working with film [22,34]. A study of images sent to an insurance company showed that there were considerably more positioning errors in the digital images than in film-based images [37].

In an early study, it was shown that about 25% of exposures performed with the first-version CCD sensor on the market, which corresponded in size to a size-0 film, needed a retake because the area in question was not included in the image [3]. More positioning errors occurred when a bite-wing examination was performed with the largest CCD sensor size in comparison to a PSP plate [33]. Other studies showed that more retakes were needed when periapical radiographs were taken with a CCD sensor compared to film, since 6% of the films were retakes, while this was the case for 28% of the sensor images [38], and in a more recent study retakes were three times more frequent with a CCD sensor than with film [39]. For examination of mandibular third molars, twice as many images needed to be retaken when a sensor was used than when using a PSP plate or film [40].

In conclusion, it seems that the prediction of fewer retakes with intraoral digital imaging than with film may be false. When positioning errors result in retakes, the time taken and the dose to the patient are obviously increased. Even though the sensors are more radiation-sensitive than PSP plates for a single exposure, it may be that this advantage is lost because of more retakes in the daily clinical situation, as concluded above.

Dynamic range of the receptor

A claimed advantage of intraoral digital receptors was that most receptors possessed a wider dynamic range than film, i.e. how large a variation in radiation dose the receptor allows whilst still producing an acceptable image. A search of PubMed using the words "dynamic AND intraoral AND radiograph*" resulted in five studies. Three more were found by a hand search.

Studies agree that PSP plate-based images possess a wider dynamic range than most sensors for exposing diagnostically acceptable radiographs [7,29,41–43], but PSP plate systems also differ in exposure range [44]. Tests of the ability of different intraoral receptors to produce an acceptable image of a low-contrast object showed that film, PSP plates and some sensors had a broad dynamic range, whereas CMOS sensors in particular had a narrower dynamic range, and a recently marketed sensor had the narrowest range of all in the test [45]. A number of sensors have quite a narrow dynamic range, and no image was captured when the radiation dose was either too high or too low [45].

The 'blooming' phenomenon occurs in some sensors in connection with overexposure. This means that pixels in a certain area 'burn out' and appear black or 'dead' in the image. An explanation for this is that an overflow of energy takes place in some of the ports. This is due to the fact that the limit of the sensor's dynamic range is exceeded, and pixels in certain areas are oversaturated. This reduces the quality of the image and can complicate the interpretation in, for example, the cervical areas where it may first appear. In addition, the marginal bone crest may be lost in the image, which can be misinterpreted as bone loss. This phenomenon was seen for some CCD sensors, while the CMOS sensors did not 'bloom' [46]. Moreover, for some sensors a relatively small image-activating area, a 'trigger zone', exists, which needs to be irradiated before an image can be created [46].

In conclusion, studies have confirmed that the dynamic range of PSP plate systems is wider than for sensors and film, which means that retakes with PSP plate systems will rarely be needed due to incorrect exposure times. On the other hand, with the large dynamic range of PSP systems, overexposure may occur without it being noticed by the operator. CCD sensors in particular have a smaller dynamic range and may bloom at overexposure, which means that retakes may be needed. It seems that recently marketed CMOS sensors have narrower dynamic ranges than previous CCD sensors; but CMOS sensors may not have blooming problems. This needs to be assessed in future studies.

Information to the patient

One expected advantage of a digital image on a monitor was that it would facilitate the way the dentist communicates the radiographic information to the patient. A search of PubMed using the words "communicate*/inform* AND patient AND digital AND radiograph*" resulted in 27 studies, none of which were original research.

A recent study, which is in press [47], showed that no additional patient satisfaction with the information was obtained by displaying and explaining the radiographic information to the patient before lower third molar surgery. There was no difference in patient satisfaction depending on whether the dentist's information was based on film radiographs or digital images.

In conclusion, no evidence exists that displaying the digital radiograph and explaining the information will benefit the patient, and more studies are needed on this topic.

Image storage, archiving and communication

The way digital images are stored, archived and disseminated has been claimed to have great advantages compared to conventional film. The digital image is captured in its original, uncompressed, image format. The intraoral image files take up between 290 and 16,000 KB of storage space depending on their resolution [10]. Compression is possible before storage; however, the irreversible image compression algorithm Joint Photographers' Expert Group (JPEG) changes the pixel values permanently (hence the word 'irreversible'), leading to a permanent change of the original image data [48–50]. Further, the digital image may be imported into software in which the original image information can be changed, invisible to the observer. A search of PubMed using the words "compression AND digital AND radiograph* AND dent*" resulted in a total of 32 studies, 12 of which focused on original research on intraoral digital images. A search of PubMed using the criteria "fraud AND digital AND radiograph* AND dent*" resulted in a total of 12 studies, four of which were original research.

Studies have assessed the effect of various JPEG compression rates and have found a continuously impaired diagnostic accuracy for proximal caries lesions the higher the JPEG rate [51], and a severe impact of high compression on the detection of periapical lesions and dentinal caries [52,53]. Others have found that moderate compression rates did not impair the diagnostic yield of caries or periapical lesions [54–56]. Which details may be lost in a compressed image depends on the original image data [57], and a review paper concluded that moderate compression rates can be used in daily clinical practice [58]. Nevertheless, for primary image storage it may be recommended that no image compression is used, and that an automatic back-up function secures all electronic data in the dental clinic [59]. Digital images may be sent via the internet. The image is exported from its database into a known image format (e.g. tif or bmp). If image enhancement is used before export, the settings are usually kept in the exported image. The image file should be encrypted if it contains patient data.

Unlike film, it may be easy to make changes to the digital image, invisible to the clinician, with the intent to defraud [60]. In one study, artificial dental disease was added to digitized radiographs and the 'treatment plan' was authorized by insurance companies [61]. General dentists were not able to recognize digital images edited with respect to added or removed implants [62], and it has been suggested that a standard authentication procedure should be implemented for digital radiographs to protect the radiographic examination from fraud [63].

In conclusion, compression of the image file, whether reversible or irreversible, can save storage space, but since hard disk space is inexpensive, it cannot be recommended to store images in irreversible compressions. Huge data files may be compressed for submission on the internet, and thus the raw data are kept. There seem to be no reports that have documented fraudulent behavior or gains made by changing digital image information in dental clinics, but the possibility exists. Insurance companies could demand to view the original digital image in its original program, thus confirming that it has not been exported to other software.

Owing to the wider use of intraoral digital radiography in the dental clinic in recent years, some disadvantages and unexpected aspects of digital imaging have been experienced, but have not yet been focused on in literature reviews. In the following sections, some of the new challenges in the work flow of radiographic examinations, such as patient discomfort, damage to the receptor and degradation of the image, cross-contamination and viewing conditions, are discussed.

Patient discomfort

The sensors are much thicker than film and most of them are connected to a computer by a cord, which can be stiff and difficult to position. Some phosphor plates are placed in a plastic envelope with sharp edges, and their corners cannot be bent. The digital receptors can therefore cause problems for the patient and the examiner during the examination. This disadvantage was not considered in early reviews of digital imaging. A search of PubMed using the words "digital AND intraoral/bitewing AND discomfort" resulted in five studies. In addition, one questionnaire study was included.

A CCD sensor ($32\times45\times7.5$ mm^3 outer measurements) and a PSP plate ($35\times45\times2$ mm^3 outer measurements) were compared by patients who recorded their perception of discomfort in connection with a bite-wing examination [33]. Patients recorded more discomfort with sensors than with phosphor plates [33,64]. In a recent study of bite-wing examination with the same type of sensor (i.e. CCD), patients compared the sensor and film, and 76% reported that the sensor was more unpleasant than film, while 15% reported that they were similar [65]. A corresponding study compared patient discomfort during examination with three sensors, two phosphor plates and film for exposure of mandibular third molars. All digital receptors felt more unpleasant than the film [40]; PSP plates were less unpleasant than sensors, and thick sensors with a cord were more unpleasant than thinner sensors and sensors without a cord. In another study, no difference was found in the perception of discomfort between a sensor with a cord and the same type of sensor without a cord for periapical radiography [5].

In a questionnaire study, pediatric dentists reported that sensors were less well tolerated by young children than phosphor plates [24].

In conclusion, sensors seem to be perceived by patients as being more unpleasant than PSP plates and film for intraoral radiographic examinations. If the patient has difficulties in tolerating the receptor in the mouth, positioning errors may occur, and this may eventually have the effect that more retakes are needed with sensors than with PSP plates.

Damage to the receptor and degradation of the image

Early reviews did not focus on the differences between film and digital systems with respect to image artifacts due to receptor damage. A search of PubMed using the search criteria "damage/artifacts AND sensor/plate" resulted in six studies, two of which were original research of the durability of digital receptors, and the search criteria "scanning/degradation AND storage phosphor plate" resulted in 12 studies, three of which were original research. In addition, seven studies were found by a hand search.

In a clinical environment, 0.4% of almost 16,000 scanned PSP images showed errors due to defective plates and 0.2% due to scanning [66]. A study showed that the main reason for the replacement of plates was damage to the phosphor layer, and methods for reducing potential damage to the plate were suggested [67]. A study has shown that a previous make of PSP plate revealed visible scratches with a load of 20 g, whereas more recent makes of PSP plate showed scratches with a load of 50–100 g [46]. A previous study showed that older plate types were determined 'non-diagnostic' after having been used ≈ 50 times [68].

The PSP plate can to some extent tolerate light during insertion into the scanner. The scanner can be placed in a room with normal daylight or room-lighting. Several studies have shown, however, that the higher the light intensity and the longer it lasted, the greater the loss of information in the plate [25,69,70]. Even though the plate remained wrapped after exposure, degradation was visible after a few hours [71,72]. Provided that the plate was placed in complete darkness before scanning, no change could be noticed in image quality even after several days [71].

Some scanners have a built-in light source ensuring that the plate is completely 'cleansed' of information before it is returned from the scanner; in other scanners one has to expose the plate to strong light to ensure a 'clean' plate before the next exposure. One study showed that there was no difference in the quality of the subsequent image after the plate had been exposed to visible light for 5 and 98 s [26].

Physical damage can occur to the sensors if they are dropped on the floor or if a patient bites hard into the surface. In a questionnaire study involving general dental practitioners, approximately 50% of sensor users stated that they had had technical problems with their sensor, 30% of which resulted in repair [22]. In a recent survey, pediatric dentists stated that the major disadvantage of phosphor plates was that they were less durable than sensors when used for children [24].

In conclusion, mechanical wear and trauma influence the lifespan of PSP plates and sensors in dental practice. This affects the cost-effectiveness of these systems compared to film. There seems to be no documentation of the lifespan of the sensors or scanners for PSP plates. Exposed plates may lose information if exposed to light before they are scanned. The stronger the light intensity, and the longer the plates are exposed to light, the greater the loss of information. If not completely protected from light, it seems that the plates should be scanned soon after exposure, and the scanner placed in an area without strong sun or lamp light.

Cross-contamination and hygienic precautions

In contrast to film, the same digital receptor is used for examination of many patients, which means that cross-contamination may be a problem. PSP plates are carried from the mouth to the scanner and potentially constitute a larger problem than solid-state sensors. The sensors can be wiped with an alcohol-impregnated tissue, but it has not been studied to what degree the plates tolerate wiping. None of the digital receptors can be sterilized. A search of PubMed using the words "digital AND cross-contamination" resulted in 10 studies, four of which dealt with digital intraoral receptors and infection control. Use of the word 'hygiene' added nothing to this result.

If the plastic envelope covering the storage PSP plate was cleaned with soap or wiped with an alcohol-impregnated tissue before it entered the scanner, two studies showed that cross-contamination was not a problem since bacteria from the oral cavity could not be cultured from the plates [64,73]. One study found that the traditional plastic sheaths covering the sensor during exposure leaked after a single exposure in about half of the cases [74]. Usage of a latex finger cot stretched over the sensor resulted in less contamination in another study, but still not to an acceptable level [75]. Both these studies therefore recommended that both a plastic sheath and a finger cot should be used, particularly when sensors are used during invasive procedures such as implant surgery [74,75].

In conclusion, precautions against cross-contamination should be taken when using digital receptors as opposed to film for intraoral radiography. A two-layer barrier seems to prevent contamination of the receptor. Studies are needed to determine to what extent present-day PSP plates tolerate being wiped with an alcohol-impregnated tissue or other disinfectant.

Viewing the image

The digital image must be viewed on a computer monitor. Monitors are available in many sizes and at many price levels. If needed, the digital image may be printed in some form of hard copy. A search of PubMed using the words "monitor AND display AND digital AND radiograph*" resulted in 118 studies, eight of which were original studies with a focus on dental, intraoral images. In addition, one more original study (in press) was included.

An early study showed that diagnostic accuracy was just as high when the image was viewed on a desktop CRT monitor as on a laptop LCD monitor or film [76], and a second study similarly found no difference between four monitors for detection of mechanically created lesions [77]. More recent studies have assessed various types of LCD monitor and found that high-priced, high-resolution, digital (so-called diagnostic) monitors were no more accurate than analog, low-priced monitors when used for detecting caries [78,79] or when used for detecting mechanically created lesions [80]. However, contrast and brightness are often not optimally adjusted in dental clinics, as documented in one study [81], and this was shown to influence diagnostic accuracy [82]. It was documented that room light should be no more than 50 lux when assessing digital images to obtain the most valid diagnostic yield [82], and another study showed that fewer caries lesions were detected on a laptop computer in an environment with strong light in the clinic than when the monitor was hooded [83]. One study found that digital intraoral radiographs assessed on glossy paper had the same diagnostic accuracy as when the same images were assessed on a monitor [84].

In conclusion, there seem to be no clinically significant differences between current clinical monitors for viewing dental digital images. Despite their high resolution and price, digital 'high-quality' monitors and gray-scale medical monitors seem to affect the diagnostic outcome very little; however, it has yet to be studied how the age of analog as well as digital monitors influences diagnostic outcome. To obtain the highest diagnostic yield it is recommended to view the images on a hooded monitor or in a room with a light level of < 50 lux.

Overall, changing from analog to digital radiography is a revolution, especially for those who worked for many years with film radiographs. Working routines, such as image capture, viewing and archiving, as well as the quality assurance of the radiographic process, are completely different. In most countries, quality-assurance programs for digital radiography are defined by the health authorities. These may include control of the receptors for physical damage, e.g. for PSP plates there may be weekly controls for the presence of diagnostically compromising scratches, and for monitors, contrast and brightness should be continuously controlled. In addition, audit programs could register numbers of exposures and re-exposures, and in large departments the opening of the digital images by the referring dentist may be supervised [85]. There seem, however, to be no studies on whether a training phase is more important when starting to work with digital compared to film radiography.

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