DIGITAL IMAGE RECEPTORS IN DENTISTRY - A REVIEW


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Abstract- Digital image receptors make an essential contribution to the processes of examination, diagnosis and treatment planning in dentistry. Digital image receptors are gaining popularity and many dentists are considering changing from conventional films to image receptors since digital technology has the potential to improve diagnosis, facilitate patient treatment procedures and streamline storage, transfer and retrieval. The aim of this review is to provide an outline of the principles and discuss the various types of digital image receptors used in dentistry.

Keywords- Digital image receptor, Charge coupled device, Complementary metal oxide semiconductors, Flat panel detectors

Introduction

For many years the contribution of radiography to the diagnosis of maxillofacial diseases has been the subject of extensive research. Digitalization has reduced the required radiation dose for dental imaging, allowed the use of image enhancement and brought an overall easier and faster workflow. Furthermore, the amount of quality assurance steps has been downsized due to the elimination of the many processing steps of conventional film development, with the final diagnostic quality of digital images now mostly depending on a specific sensor's sensitivity profile, resolution and the X-ray generator's exposure settings. The implementation of digital image analysis in dentistry could result in greater diagnostic accuracy, because it enables the enhancement of specific features of interest [1]. This article aims to introduce principles by which digital image receptors work and also to discuss various types among them.

Principles of Digital Image Receptors

Digital detectors are used only to generate the digital image, which is then stored on a digital medium. Digital imaging comprises four separate steps: generation, processing, archiving, and presentation of the image. The energy absorbed by the detector must be transformed into electrical charges, which are then recorded, digitized, and quantified into a gray scale that represents the amount of x-ray energy deposited at each digitization locus in the resultant digital image. After sampling, post processing software is needed for organizing the raw data into a clinically meaningful image. After final image generation, images are sent to a digitized storage archive. A digital header file containing patient demographic information is linked to each image. Although it is possible to print digital images as hard-copy film, the advantages of digital radiography are not realized completely unless images are viewed digitally on a computer workstation [2]. Digital images may also be integrated into electronic charts and transported by teleradiography with the help of Digital imaging communication in medicine software (DICOM) [3] [Fig-1].

Advantages of Digital Image Receptors

Digital x-ray sensors have several advantages such as: immediate image production with solid-state devices; interactive display on a monitor with the ability to enhance image features and make direct measurements; integrated storage, providing access to images through practice management software systems; security of available backup and off-site archiving; perfect image duplicates to accompany referrals to other practitioners; security mechanisms to identify original images and differentiate them from altered images; ability to tag information such as a patient identifier, date of exposure and other relevant details; superior gray scale resolution; reduced exposure to radiation [4].

The digital image receptors are basically classified to direct and indirect. Direct digital image receptors include charge coupled device (CCD) and complementary metal-oxide semiconductor (CMOS) detectors; whereas indirect digital image receptor include photostimulable phosphor plate (PSP) system [5].
CCD

In a CCD sensor, the charge or electric signal is read by transferring the collected charge in each pixel, in a serial fashion to a readout amplifier. The same photon-generated charge collected at each pixel site is transferred (coupled) pixel by pixel (similar to a bucket brigade) in a predesigned sequence that cannot be interrupted. When the pixel charge is transferred to the readout amplifier, it is destroyed. Next, the output from the CCD is digitized. A special hardware converter (analog-to-digital converter [ADC]), separate from the sensor, then takes the voltages generated by the individual elements of the CCD and rounds them off into the number of alternative values to be used to represent the image digitally [6]. For scanning systems it is usually more practical to operate the CCD in time delay integration (TDI) mode. Here, a storage section is not required as the charge is simultaneously captured and shifted down the CCD detector columns toward the horizontal readout register. This type of analogue integration is desirable as it is relatively noise free. In addition, because all of the detector elements in a column contribute to each image pixel imaged by that column, the image produced by TDI is relatively insensitive to a few pixels in the column that may suffer from abnormally low or high sensitivity [7]. In the case of the CCD, usually silicon is used as the base material and silicon dioxide is used as the coating. The final, top layer is also made of silicon - polysilicon [7,8][Fig-2].

PSP

The image plate method involves the use of a phosphor storage plate (PSP). This plate stores energy after exposure to radiation and emits light when scanned by a laser. The scanner stimulates the phosphor plate and stores a record of the number of light photons detected. Loading of the scanners generally only requires subdued lighting as the plates are slightly sensitive to visible light. However, some products are lighter sensitive than others. The lasers used are centered on the 600-nm band and are usually of the helium-neon variety. Scanners, the size of a bread maker, can accommodate multiple image plates at any one time. The exact numbers vary between manufacturers. There is a delay while the image is 'developed' before it appears on the monitor. Up to eight bitewing radiographs take about 90 seconds and a panoramic image can take approximately 3 minutes to be scanned. Again, the scan times do vary between manufacturers. Although the plate can store energy for a number of days, information starts to be lost within minutes after exposure and it is advised to scan the plates quite quickly to optimize the image recovered. To fully remove the latent image the plate should be exposed to high intensity light. Image plates are available in exactly the same sizes as conventional film and come with disposable plastic barriers. They have no wires attached and are reusable for thousands of exposures, but do need careful handling to avoid surface damage. Current systems have a spatial resolution of 6-8 LP/mm [11][Fig-3].

CMO - Active Pixel Sensor

In the early 1990s monolithic pixel sensors have been proposed as a viable alternative to CCD's invisible imaging. These sensors are made in a standard VLSI technology, usually CMOS, which is the reason why they are often called CMO imagers. Two main types of sensors exist: the Passive Pixel Sensor (PPS) or the Active Pixel Sensor (APS). In the former, a photodiode is integrated in a pixel together with selection switches, which connect the photodiode directly to the output line for readout. In the latter, an amplifier integrated in each pixel directly buffers the charge signal. Today most CMOS imagers have an APS structure because of its better performances [9].

Active-pixel sensors (APs) reduce the noise associated with passive-pixel sensors. Each pixel has an extra circuit, an amplifier, which helps cancel the noise associated with the pixel. The performance of this technology is similar to charge-coupled devices (CCDs) and also allows for a larger image array and higher resolution [10].

Flat-Panel Detector (FPD)

Flat panel detectors are being used for medical imaging but also have been used in prototypes of extra oral imaging devices. The detectors can provide relatively large matrix areas with pixel size less than 100 microns. Two approaches have been taken in selecting x ray sensitive material for FPD: indirect and direct. Indirect detectors are sensitive to visible light and an intensifying screen (caesium iodide (CsI)) is used to convert x-ray energy into light. These devices are limited by the thickness of intensifying screen [12]. The electronic flat-panel detector allows direct digital recording of X-ray images, without the intermediate step of optical or mechanical scanning. The essential part is a semiconductor layer of amorphous silicon, divided into a matrix of individual sensors; each with a width of 0.143 mm. Silicon on its own is not sufficiently sensitive to the X-ray energies. For this reason, the layer of amorphous sili-
con is coated with an image-conversion layer, which absorbs the X-ray photons and emits photons of visible light. These can be detected extremely well in the silicon layer [13].

The advent of flat-panel imagers (FPDs) applied to cone-beam CT appears to offer a promising technology for volumetric imaging, providing 3-D visualization of soft and bony tissues with excellent spatial resolution (typically sub-millimeter). This technology could potentially deliver a powerful and elegant solution for IG procedures by combining the speed and flexibility of digital radiography / fluoroscopy with the wealth and quality of spatial information provided by volume CT - in a single device and in an open geometry [14].

**Conclusion**

Digital image receptors have contributed to the advancement of radiographic imaging in dentistry. Digital image receptor systems utilize computer technology and radiation sensitive detectors that capture the image, convert it into numeric data and permit image display on a monitor. Digital images may be enhanced once acquired, conveniently stored, accessed, printed or transmitted. Digital image receptors reduce patient radiation exposure and eliminate the need for the darkroom and chemical processing.

**Conflicts of Interest:** None declared.

**References**


