Digital Imaging in Dentistry: A Review

Historical Background

X-rays were discovered in 1895 by Wilhelm Roentgen. Digital radiology has overtaken conventional screen-film radiography since it was introduced in the mid-1980s.[1] Digital imaging uses sensor of solid-state, and information is presented and stored as an image using a computer. The dawn of the digital era in dental radiography came in 1987 with the first digital radiography system called radio visio graphy (RVG), launched by Dr. Francis Mouyen. A physicist and charge-coupled device (CCD) image sensor design engineer Paul Suni created the CCD image sensor technology that made the RVG digital radiography system a reality.[2] Main factor distinguishing digital systems from conventional is their response to incident radiation. An imaging system operates between the range of a completely bright and a completely dark image. The dynamic range of digital detectors is about 400-fold compared to film-screen.

Digital Radiography

Digital radiographic images can be indirect, direct, or semi-direct. Radiographic produced by flatbed scanners with a transparency adapter, slide scanners, and digital cameras are referred to as indirect digital radiographs. Direct digital images are acquired using a solid-state sensor such as CCD or complementary metal–oxide–semiconductor (CMOS)-based chips. Semi-direct images are obtained using a phosphor plate system charge-coupling transfers the number of electrons deposited in each pixel from one well to the next in a sequential manner to a readout amplifier for image display on the monitor. Area digital sensor array is used for intraoral radiography while linear arrays are used in extraoral imaging. CMOS sensors use an active pixel technology. It reduces required system power by a factor of 100 and eliminates the need for charge transfer. Phosphor plate system consists of a polyester base coated with a crystalline emulsion of europium-activated barium fluorohalide Compound. Incident X-ray photons create a latent image. A scanner reads the image information by scanning the plate with a laser beam of near-red wavelengths to form digital image.

Clinical Applications

Contrast resolution is an important parameter in the diagnostic accuracy of caries detection. Software allows image manipulation by applying specific filters to detect carious lesions. For periodontal diagnosis, the high resolution of intraoral radiography helps the visualization of the bony supporting tissues, including small details such as periodontal ligament space, lamina dura, and bony trabecularization.[3] Digital imaging allows measuring bone loss extent using image analysis tools. High-resolution technology and/or dedicated endodontic filtering improves the visibility of small file tips as small as 0.06 mm. Serial radiographs with identical geometric projection and exposure settings can be subtracted using digital subtraction radiography. This allows for qualitative evaluation by underscoring small changes such as caries progression, periapical lesions, or even quantitative evaluation of periodontal bone loss.[4] Forensic dentistry uses radiology in determining the age of an individual by assessing the stage of eruption of teeth as well as for evidence in the identification of the suspect, to determine the cause of death, to find faulty charting of teeth, legal matters, body identification, postmortem examination, and for nonaccidental injuries of children and forensic anthropology.[5] In evaluating cysts or benign tumors, multiplanar sections (axial, coronal, and sagittal planes) are helpful to locate deeper tissues. It is also helpful in postsurgical follow-ups of lesions with high recurrences.

Advantages

Digital radiography requires 90% lesser dose compared to E-speed film. In digital imaging, image quality may be interactively manipulated after image acquisition, i.e., contrast, blur and noise may be altered digitally. Filtering of the digital image may result in a reduction of blur of structure boundaries. Diagnostic accuracy of the detection of carious lesions is increased by digital contrast enhancement and filtering. Measurements of length, angle, and area can be made on a digital image. Three-dimensional reconstruction of radiographic images is of importance for the diagnosis and treatment planning in malformations, trauma, tumor investigation, and surgery planning. Low-pass spatial filtering (smoothing) reduces the image noise. However, it decreases image resolution. High-pass spatial filtering (hardening) enhances edges to create a crisper image, but with more noise. It facilitates the detection of boundaries of low-contrast regions. In digital radiography, the same image can be used for

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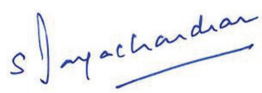
various diagnostic purposes, for instance, marginal bone loss which requires lighter images and caries detection requiring darker images. With the CCD system, the image is displayed immediately postexposure. Although there is a lag time between scanning and the appearance of an image exists with the pressure-sensitive paint method, it is faster than the conventional method. Digital Imaging and Communications in Medicine (DICOM) standards encompass primary and secondary diagnostic images acquired digitally that provides a basis for interoperability of digital system's output.[6] DICOM standard facilitates a common method of transmission for medical radiographic images. DICOM compliant system utilizes common file formats that are universally recognized. For instance, when one is contemplating digital image submission to insurance companies.



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