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Chapter 34

Advances in Radiographic Techniques Used in Dentistry

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1. Introduction

Conventional radiographic techniques have been used in dental radiography since the discovery of the x-rays. With the revolution in electronic systems, equipment’s have been produced to achieve a radiographic image in a digital format. Digital images are in numeric format and differ from conventional radiographs in terms of pixels, and the different shades of gray given to these pixels [1].

A digital image is produced by analog-to-digital conversion (ADC). First, the small ranges of voltage values in the signal are grouped together as a single value. Second, every sampled signal is assigned a value and stored in the computer. Last, the computer organizes the pixels in their proper locations and displays a shade of gray corresponding the number assigned and the image becomes visible on the computer screen [1].

Two dimensional and three dimensional digital imaging modalities have been developed for dentomaxillofacial diagnosis, treatment planning and several clinical applications. These modalities consist of digital intraoral imaging, digital panoramic and cephalometric imaging and cone-beam computed tomography.

The knowledge of advances regarding radiographic techniques and proper use of them gives the opportunity to the practitioner for improvement in diagnostic tasks and treatment planning. Therefore, the aim of this chapter is to focus on the requirements, applications, advantages and disadvantages and artifacts of the currently available digital imaging techniques according to the literature.

2. Two dimensional digital imaging in dentistry

Two dimensional imaging is an adjunct of clinical examination in dentistry. It has an important role in the diagnosis of dental pathologies and treatment planning.
Two-dimensional imaging could be broadly categorized as intraoral and extraoral imaging. Intraoral imaging includes periapical, bitewing and occlusal projections, while extraoral imaging includes panoramic and cephalometric projections. These both were acquired with conventional radiography; which is a technique using films, cassettes and wet film processing for long time, but nowadays with the introduction of digital systems they could be achieved with digital imaging.

Two-dimensional digital imaging systems have been considerably improved since their initial introduction. This improvement in type, size, shape, radiation effective dose, and resolution of the sensors made them to be adopted in routine use in dental clinics [2,3]. The diagnostic performance of two-dimensional digital imaging systems was found to be comparable with conventional radiography. Studies reported the usefulness of digital imaging in caries diagnosis [4-6], periodontal bone defects [7-9], endodontic applications and diagnosis of periapical lesions [10,11], root fractures [12] and root resorption [13,14].

2.1. Digital intraoral imaging

Digital intraoral imaging could be achieved by periapical, bitewing and occlusal projections. Periapical images show the crown and root of the investigated tooth/teeth and some of the surrounding structures. It is useful in dentistry as it shows the entire image of tooth/teeth, periapical region and some of the surrounding structures. Bitewing images show only the crown of the tooth/teeth and part of the root(s), but allow the visualization of both the maxillary and mandibular teeth crowns and alveolar crest in one image. Occlusal images show the palate and the floor of the oral cavity and a larger area of teeth and surrounding structures compared to periapical and bitewing projections. Assessment of bucco-lingual direction of interested regions is also possible with the cross-sectional occlusal technique. It is useful for the examination of the palate and floor of mouth and for the anterior teeth when patients are unable to open their mouth wide enough for the placement of receptors in periapical projections. Although two-dimensional intraoral digital imaging is useful and has several advantages, the superimposition of unwanted structures is the main problem in capable of decision-making for correct diagnosis and treatment planning [15].

Intraoral digital imaging could be achieved with indirect, semi-direct and direct digital intraoral techniques. The dentists should have knowledge about the requirements, advantages and disadvantages of these systems in detail to maximize benefits and safe use of the systems.

**Indirect Digital Intraoral Imaging:** In this method, conventional radiographs (analog images) are transferred to digital medium with the aid of a flatbed scanner with a transparency adapter, a slide scanner and a digital camera. It is a simple way to obtain a digital image and it is less expensive compared to semi-direct and direct digital systems. This technique was used more commonly at the beginning of digital image acquisition. With the improvement and widespread of other digital techniques, it has lost its popularity nowadays [16].

**Semi-Direct Digital Intraoral Imaging:** Semi-direct digital intraoral imaging is possible with a system using photo-stimulable phosphor coated plates (PSP) (Figure 1). These plates are placed in the mouth of the patient and exposed to x-rays. After the exposure, they are scanned
with a special laser scanner system and the latent image becomes visible on the computer monitor [17]. The latent image is erased by exposing the plates with bright light prior to a new x-ray exposure after the plates are scanned [18,19].

The plates should not be exposed to light because this will release some of the energy captured by the plate before it is scanned and degrade the quality of the radiographic image. Hence, the plates exposed to x-ray should be kept in subdued light environment prior to scanning. [18]

Different types of scanners are present. Some of the scanners can only one plate in each step, and other are capable of scanning more than one at each scan. [19] Scanning time also differ among modalities from 4 seconds to several minutes and according to the spatial and contrast resolution of the image.

Similar to films used in conventional radiography there are different sizes of plates, including child size, adult size, adult bitewing size and occlusal size and they can be used with the film holders used in conventional radiography [20].

Semi-direct digital imaging is a more comfortable technique for patients’ compared to direct digital intraoral imaging as the plates’ are flexible to some extent and the size, shape and thickness are similar to films used in conventional radiography [21].

Direct Digital Intraoral Imaging: Direct digital intraoral images could be achieved with solid-state sensors. There are two types of solid state-sensors; charged-coupled device (CCD) and complementary metal oxide semiconductor (CMOS).

CCD sensors: A solid state silicon chip is used to record the image in this technology. Silicon crystals convert absorbed radiation to light and the electrons constitutes the latent image according to the light intensity. This signal is sent to the computer with a cable connecting the sensor and the computer, and the image becomes visible on the screen (Figure 2) [1,19].

CMOS sensors: This technology was adapted to intraoral digital imaging after the CCD sensors were invented. These sensors have a similar working principle with CCD, only the chip design differ in terms of integration of the control circuitry directly into the sensor [16]. CMOS sensors are less expensive than CCD’s [1]. Initial CMOS systems had a cable connected to the sensor and computer, but nowadays cable-free type is also produced. In cable-free type, the radiographic data stored in the chip are transferred to the computer in radio-waves with the aid of a stationary radio-wave receiver connected to the computer. The manufactures instruction recommends the distance between the sensor and this receiver should not be more than 180cm, but in a study it was reported that this distance could be more than this, but should not exceed 350cm [22].

2.2. Digital extraoral imaging

The revolution in digital extraoral radiography includes digital panoramic imaging and digital cephalometric imaging. Digital extraoral and panoramic systems have not been widely adopted since their first introduction in the dental market (Figure 3). This was due to their very high costs. Sometime after their invention, relatively cost effective systems with improved computer settings (computer speed, data storage capacities) have been manufactured and they