Original Research Paper

VOLUME-6 | ISSUE-1 | JANUARY-2017 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 78.46

Advances in Dental Radiography

Dental Science

KEYWORDS: CBCT, Micro CT, RVG, Digital Radiography

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ABSTRACT

The use of radiographs as a diagnostic tool has become an indispensable routine in dental therapy. The advent of 3D imaging has provided the dentist with tools that weren't available to the clinician before, and facilitated interactive image manipulation and enhancement to visualize the area of interest as a 3D volume. Conventional CT is a non invasive method of evaluating certain aspects of endodontic instrumentation such as canal transportation, dentin removal and final canal preparation. Cone beam CT is relatively new three dimensional imaging techniques requiring a significantly lower radiation dose than conventional CT. It provides high resolution and isotropic images in comparison to conventional CT. All these imaging modalities have introduced many potential benefits to dental practice making it simpler and accurate.

INTRODUCTION

The imaging techniques in dentistry allow the definition of the root and canal morphology, and particularly the determination of endodontic working length and final verification of the outcome of the root canal treatment (Versteeg et al, 1997)[1].The technological advances have led to the introduction of digital radiology with many potential benefits in endodontic practice (Mouyen et al, 1989)[2], (Shearer et al 1990)[3], (Horner et al 1990).[4] Three dimensional (3D) imaging modalities have provided new dimensions in Dentistry.

ADVANCES IN DENTAL RADIOGRAPHY INCLUDE:

Digital Radiography

In Radio Visio Graphy instead of silver-halide grains as in a conventional radiograph, a large number of small light-sensitive elements in a sensor are used to record the image . To display the image, different shades of gray are produced by the amount of light emitted from the monitor screen. The fundamental difference between both methods is the fact that in the analog radiographic image, the silver grains are randomly dispersed in the emulsion, whereas the electronic elements of a digital sensor are arranged in a regular grid of rows and columns. The quantitative characteristics of the light-sensitive elements of the electronic sensor result in gray shades having a discrete value; the gray shades in the analog image depend on random local distribution of the silver grains, which means that they can produce any amount of opacity between completely bright and completely dark. CCD (Charged coupling Device)/CMOS (Complementary Metal Oxide semiconductor) sensors appear to offer the best contrast and spatial resolution, in the digital radiography, in addition to facilitating instantaneous image capture; thus are recommended for dental applications. Radio Visio Graphy was preferred because of the significant reduction in radiation dose. (Leddy BJ 1994) [5]

Photostimulable Phosphor Radiography

Storage phosphor plate technology is based on the principle of luminiscence, allows indirect production of radiographic images using a semiflexible, phosphor-coated plate. The plates are loaded into a sheath, exposed, mounted in a carousel, and then placed in the scanner. These plates are available in periapical, panoramic, and cephalometric sizes, and they support a wide range of exposure settings.

A radiographic digital imaging technology, photostimulable phosphor radiography (PPR), has potential to improve dental radiography and is likely to become increasingly common over the next few years. [6]

Digital Subtraction Radiography

Digital subtraction radiography is a sensitive method for detecting changes in radiographic density over time.[7] It may be especially useful for evaluating osseous healing after treatment as an aid in diagnosis. By definition subtraction radiography requires that two images have nearly identical image geometry; with specialized positioning devices and bite registrations aid in matching the images.

The subtracted image is a composite of the images representing their variations in density. By subtracting all anatomic structures that have not changed between radiographic examinations, changes in diagnostic information become easier to interpret. Any change is displayed on the resultant image against a neutral, gray background. [7]

Xeroradiography

The process of xeroradiogrpahy has been described in varying detail by McMaster, Rawls and Owen, and Boag and associates. In brief it involves the use of x-radiation to discharge a selenium plate which has received a positive electrostatic potential. The pattern of discharge is comparable to the latent image of a photographic emulsion. This image is made visible by blowing negatively charged powder particles ("toner") over the plate. The powder is selectively attracted to the regions of residual positive charge. The final image is generally transferred to a plastic coated paper and the selenium plate is recharged and reused.[8]

Xeroradiograph is slightly superior to the conventional radiograph in its ability to depict carious lesions and ossesous radiolucencies. The advantage is more clearly demonstrated in some applications than in others, with root canals and periodontal ligaments appearing particularly distinct.It also offers more diagnostic information in interpretation of root apex structures and of periodontal ligament structures.[8]

Computed Tomography CT

It combines thin section imaging with electronic image acquisition and computerized image generation. These images are taken in succession and are generally referred to as slices. Information from multiple slices can be reformatted to produce images in the coronal, sagittal or panoramic orientation.

3D images can also be generated from these data. The matrix size of

an image refers to the number of discrete picture elements or pixels. The volume of tissue is represented in a voxel which can be calculated by multiplying the pixel dimensions by the slice width.

The image can be electronically processed, viewed in different orientations and with different density parameters. The ability to view a CT image using different density parameters can be achieved through the process of windowing an image. Windowing allows the operator to select the range of densities to be viewed (window level) and the number of gray levels to be viewed (window width).

CT has always been considered a high radiation dose technique. Several parameters affect the patient dose, including the area being imaged, the number of slices, the thickness of the slice, and the kilovolt peak. Dental applications for CT:Assessment of paranasal sinuses, trauma, TMJ, Implant assessment.

Velvart P et al (2001)[9] concluded that the use of CT provides additional, 3D information not available from conventional 2D radiographs for treatment planning in apical surgery of mandibular premolars and molars.

Micro-CT

Comparison of the effects of biomechanical preparation on canal volume on reconstructed root canals in extracted teeth using micro-CT (MCT) data was shown to assist with characterization of morphological changes associated with these techniques. Manocci et al[10] used micro CT to count the number of isthmuses detected by MCT in transverse serial sections of the apical 5mm of the mesial roots of mandibular molars and to describe the morphology of the isthmuses observed in the same sections. However micro-CT remains a research tool and cannot be employed for human imaging in vivo. But it is likely that in coming future in vivo micro CT will help in treating difficult cases in endodontic practice.

Volumetric CT (VCT) or CBCT

A relatively new diagnostic imaging modality has been used in endodontic imaging recently. This modality uses a cone beam instead of a fan-shaped beam as in medical-grade CT, acquiring images of the entire volume. It offers relatively high resolution, isotropic images in comparison with medical-grade CT images, for effective evaluation of root canal morphology. Even though resolution is not as high as that of conventional radiographs, the availability of 3D information and a relatively higher resolution then other digital radiography and a significantly lower dose than medical-grade CT makes CBCT the imaging modality of choice in challenging situations demanding localization and characterization of root canals.

Pinsky et al (2007)[11] introduced a novel periapical surgical method using CBCT and CAD-CAM surgical guides. They suggested that CBCT supported preplanning combined with CAD CAM surgical guidance can provide more accurate access to the apices without the risk of damaging the vital structures as compared to traditional approaches.

Magnetic Resonance Imaging in Dentistry

In 1946, Purcell and Bloch, two independent scientists, discovered the nuclear magnetic resonance (MR) phenomenon, which can be exploited to produce anatomic and functional information. Nuclear MR can be used to determine the electronic structure of molecules as well as to produce images. The production of images from MR is explained by the Larmor equation.

Magnetic resonance imaging (MRI) offers high soft tissue contrast and thus provides high-resolution images of blood-filled structures.[12] Different MRI methods can be used for assessing dental vitality with high sensitivity and specificity. MRI can show tooth vitality by signal intensity increase in the pulpal cavity after intravenous administration of contrast. This admittedly complex method is not suitable for routine use at the dental chair but may be helpful in cases where highly accurate measurements are required.

The results of high-quality MRI examinations can be analyzed retrospectively. This means that there is no need to repeat the MRI examination. MRI can also aid in diagnosing soft tissue lesions of periradicular region of teeth.

Teleradiology

Teleradiology is the most common application of telemedicine and accounts for the greatest number of telemedicine consultations conducted annually[13].

In 1994, the American College of Radiology (ACR) defined teleradiology as the electronic transmission of radiologic images from one location to another for the purposes of interpretation, consultation, or both. Teleradiology systems allow direct digital or digitized film images to be transmitted to distant locations, where they can be viewed and downloaded to hard copy for reading and interpretation.

CONCLUSION

With rapid advancement in sensor technology and frequent software upgrades occurring on a regular basis, selection of one system over the other for a specific diagnostic task seems to be challenging.

Three-dimensional imaging will continue to be used extensively as sensor characteristics improve and more robust software is introduced.

The advent of 3D imaging has provided the dentistry with tools that were not available to the clinician before, and facilitated interactive image manipulation.

ACKNOWLEDGEMENT

It's my pleasure to express my gratitude and sincere thanks to Dean Dr. S. P. Dange , Government Dental College & Hospital Aurangabad.

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