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Advances In The Radiographic Diagnostic Techniques In Periodontics

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Abstract

The use of radiographic imaging as an aid in the diagnosis and treatment of periodontal disease is widely accepted. Radiographs can provide critical information for diagnosis and treatment planning, which can also serve as baseline information for the assessment of treatment outcomes. Radiographs are generally considered to provide essential information for the assessment, diagnosis and management of periodontal disease. Traditional radiographic aids are inadequate for determining the sites showing active tissue destruction & monitoring the response to therapy, as well as to measure susceptibility to future periodontal breakdown. Various modalities have been evolved to overcome these limitations.This article aims to review the recent advances in the radiographic diagnostic techniques used in periodontics

Key Words

radio-graphic, digital imaging,CT, DSR, TACT, OCT, CBCT, Dentascan

Introduction

Diagnostic testing has been a great challenge in Periodontology. It is primarily derived from information obtained from the patient's medical and dental histories combined with findings from thorough oral examination. The entire constellation of signs and symptoms associated with disease and the additional information provided by radiographic imaging and laboratory tests is taken into consideration before arriving at a diagnosis. Traditional radiographic aids are inadequate for determining the sites showing active tissue destruction & monitoring the response to therapy, as well as to measure susceptibility to future periodontal breakdown. The use of radiographs as a diagnostic tool has become an indispensable routine in dentistry. With the elec-tronic era, however, more specialized equipment was introduced into different phases of the imaging procedure. This article aims to review the recent advances in the radiographic diagnostic techniques used in periodontics.

Discussion

A conventional radiographic image consists of the arrangement of silver grains in the photographic emulsion. The density of the silver grains depends on the intensity of the x-ray beam. When a radiograph is viewed on a light box using transmitted light, the pattern of the different densities of the silver grains is transferred to the eyes and perceived as different shades of gray.

Digital Image:

The electric signal that is produced by the sensor is a voltage that is varying as a function of time. The sensor is connected to a special board in the computer, called a frame grabber; the function of this board is to sample the signal at short intervals, thus converting the analog signal into a digital signal. The output of the measurements is stored in the computer as numbers. These numbers have discrete values; only integer values are possible. Usually the range of numbers is from 0 to 255 in digital imaging. Completely black is represented by 0, and white is 255. The other shades of gray have values between 0 and 255.[1],

When the image is captured and digitized by means of an electronic sensor system, the radiation intensities are measured along a rectangular two-dimensional grid of sensor elements, called pixels. The outcome of the measurement of each sensor element is transferred to the computer and stored as a number between 0 and 255. To display the image, the numbers are read out and used to control the intensities of the pixels on the monitor screen. Several methods exist to acquire a digital image.[2]

1. Conventional Radiograph Digitized, Using a Flat-Bed Scanner and Transparency Adapter
   This procedure assumes that a conventional radiograph is available. The radiograph is scanned, using a flatbed scanner with a transparency adapter. Usually the spatial resolution can be chosen such that the diagnostic details are preserved in the digital image.
2. Conventional Radiograph Digitized, Using a Charge Coupled Device Camera
   This method is similar to the previous method. The radiograph is positioned on a viewing box, and instead of a flatbed scanner, a charge coupled device (CCD) video camera is used. Depending on the software used to control the camera settings, resolution and exposure time can be adjusted.[3]
3. Semidirect Digital Image, Acquired Using Photostimulable Phosphor Plates
   Photostimulable phosphor plates can hold a latent x-ray image for some time. The latent image is the result of excitation of electrons in the phosphor crystals by the x-ray photons. Later a laser beam scans the

image plate. The electrons return to the original energy level; during this process, energy is emitted in the form of light, which can be captured by a photo-multiplier device. The output of the photo-multiplier is converted into pixel values, comprising the image information. This technology is called semidirect because of the intermediate phase of the latent image. photostimulable phosphor plates are available in sizes comparable to conventional dental film.[3]

4. Direct Digital Image, Acquired Using a Charge Coupled Device, Complementary Metal-Oxide Semiconductor, or Other Electronic Device
   In this method, the intensity of the radiation in the x-ray beam is measured directly by an electronic device consisting of a large number of light-sensitive elements. The output of these elements is transferred to the computer as an electric signal and digitized in the frame grabber board. A scintillation layer (such as a screen phosphor material) is put on top of the sensor array. X-ray photons are converted into light photons, increasing the efficiency of the detector. The size of the electronic sensors has been considerably smaller than a No.2 dental film, but currently sensors with an active area that approaches the dimensions of standard intraoral film are available.

Intraoral Detectors

Direct sensor systems are capable of real-time imaging; an image is displayed on the monitor in a few seconds. The systems are built around a CCD sensor. CCDs are arrays of x-ray-sensitive or light-sensitive pixels.[3]

A CCD is made up of a large number of photoelectric cells (several thousand) that generate voltage in proportion to the amount of light or x-rays striking them. The CCD charge 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 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.

Advantage of CCD:- Lowest noise of any competing technology.

Disadvantages of CCD devices:-

Blooming- Blooming is similar to allowing too much light through a viewbox, blinding the operator and washing out radiographic information in the excessively bright image. This blooming occurs in CCD systems by excess charge leakage to other pixels. Because commercial-grade CCDs contain some flaws, regions of bad pixels result in a partially or a totally bad column or row of pixels.

The output from the CCD is to be digitized. A special hardware converter (Analog - To - Digital converter [ADC]) 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. If 256 shades of gray are to be represented, the signal from each CCD element is converted to the appropriate value within this range. Initial sensor systems captured the image using this gray scale from 0 to 255. The acquisition and display with 256 gray values is replaced in newer systems by acquisition with 1024 (10 bits) or even 4096 (12 bits).

Complementary Metal Oxide Semiconductor

CMOS-based sensors are now finding their way into intraoral sensor systems. The first advantage of CMOS technology is design integration. The major advantages of CMOS image sensors are integration, low power, manufacturability, and low cost. Another advantage of CMOS technology is the ability to benefit from the high-volume manufacturing capacity already in place to support the CMOS semiconductor industry.[4] A CMOS chip is already in every computer in the world. CMOS sensors also permit the integration of control circuitry, including ADC, directly into the sensor. The Schick CDR sensor (Schick Technologies, Long Island, NY) is an example of the application of this new technology. On the down side, although they perform well in bright light conditions (e.g., digital photographic cameras), CMOS sensors may not perform well in low light conditions or with the rigorous demands of medical imaging systems. They have more fixed pattern noise and use some of the chip real estate or area for other operations, leaving less active area for image acquisition.

Bulk Charge Modulated Device

Bulk charge modulated devices (BCMDs) feature image performance comparable with the CCD sensors but offer improved price and performance over existing CCD sensors by using a more standard fabrication process.[4] BCMD sensors exhibit performance capabilities comparable to CCD sensors, including high sensitivity and low noise. Similar to CMOS systems, they have the advantage of the low-cost production process and presumably lower power usage.

CCD and CMOS technologies are capable of delivering images that are diagnostically equivalent to film. In any intraoral imaging procedure, film-holding beam-alignment devices should be used to improve image quality. Quality assurance with CCD and CMOS systems is inherently improved over film because of the image reproducibility and the elimination of the chemical. Mastering any sensor system, however, requires time and effort. It cannot be done vicariously.

Selected Applications For Digital Imaging In Dentistry

The most exciting areas of advancement in digital dental radiography include image processing to enhance contrast, making on the fly distance measurements, and producing three-dimensional images from a series of two-dimensional views.

Contrast Processing

To detect differences in structures in a radiograph, there needs to be sufficient contrast. This contrast primarily depends on the differential properties of adjacent tissues to attenuate the x-ray beam. It also depends on the signal received, which increases with increased exposure. Given an adequate signal and sufficient radiodensity differences, contrast can be sufficient to differentiate between adjacent structures regardless of the recording modality used. Examples of successful contrast enhancement include

1. The more accurate determination of the size of periapical radiolucencies using enhanced images.
2. For the detection of simulated dental caries under orthodontic bands

Automated Diagnosis

The movement toward artificial intelligence for automated diagnosis has taken a huge step forward. The add-on software can be applied to bitewing or periapical images by indicating the type of tooth and proximal tooth area to be evaluated. The probability of a true positive for enamel and dentine lesions is indicated. This software has not yet been applied to extraoral radiography; however, there has been interest in automated detection of cephalometric landmarks for orthodontic treatment planning and outcomes projection. Additionally, the DigiPan has an implant simulator which can be used where the width of the jaw is not easy to estimate clinically, such as when standing teeth adjacent to the proposed implant site are not far apart.

Three-Dimensional Imaging

Patients can be referred for computed tomography (CT) for presurgical evaluation of multiple dental implant sites. There are a variety of programs for simulating implant placement to assess special surgical approaches that might be needed. Although the patient generally needs to be referred to a medical radiology center for the CT procedure, the images can be processed to be viewed and assessed by the surgeon or radiologist using a simple personal computer. This ap-proach is possible using the Sim/Plant software (Columbia Scientific, Columbia, MD). For more advanced procedures, it is possible to use CT images to produce a three-dimensional laser-processed plastic model.[3]

Such models can be used to simulate the operation and to fabricate splints that may be needed during the operation.

Three-dimensional imaging is not limited to CT or magnetic resonance imaging. Stereoradiography has been available for some time but has not found favor in view of the difficulty experienced in viewing and interpreting the images. A new method has developed for producing three-dimensional images from series of two-dimensional images. This system is termed tuned aperture computed tomography (TACT). It has been licensed by Instrumentarium Imaging (Tuusala, Finland), and its application to mammography is at an advanced stage of development. Work is in progress to use TACT for dental applications by adaptations to the Instrumentarium or 100 panoramic machine.[3] This system is being promoted under the title of OrthoTACT, but the date of its introduction into the market is still uncertain.

Digital Subtraction Radiography

Digital subtraction radiography (DSR) has been developed to enhance the visualization of mineral changes that have occurred over time. To show these changes against a homogeneous background of unchanged anatomy, a high level of standardization in projection geometry and image density needs to be achieved.[4] Numerous studies have shown the high diagnostic utility of DSR relative to conventional radiography.

Color

Most digital systems currently in the market provide opportunities for color conversion of gray-scale images, also called pseudo color.[5] Although it is true that humans can distinguish many more colors than shades of gray, pseudo color is often presented as a segmentation tool to identify or label a particular object in the image. A useful application of pseudocolor is to highlight parts of the image after a segmentation operation has been applied. The use of color has also been advocated to encode multidimensional information. An application of such encoding was reported for the detection of alveolar bone changes using image addition.

Image Restoration

Image restoration operations are similar to objective image enhancement methods; perhaps the clearest distinction between these two types of operations is that image restoration is mainly concerned with undoing known or estimated degradations introduced during image formation.[4] Example include blur-reduction algorithms for cross-sectional tomography.

Image Analysis

Image analysis operations are designed to extract nonpictorial information from the image that is diagnostically relevant. Such information can range from a simple measurement to a fully automated classification procedure.[3]

Measurements

Modern imaging software provides an extensive tool kit for image analysis: a digital densitometer; digital calipers; adjustable rulers; and a variety of other tools to measure shape, texture, complexity, and a multitude of other parameters. Although some of these tools replace traditional analog instruments, others had no previous application in dental radiography and have created new opportunities for research. [2]

Segmentation

A critical step in image analysis is the process of image segmentation. Segmented images are formed by gathering its elements into sets associated with meaningful objects. The goal of segmentation is to simplify the image and reduce it to its basic components.

Feature Extraction

After segmentation of objects in the image, a variety of features can be measured that assist in determining to what class each object belongs. In dental radiography, features of interest include measures of size and shape, relative location, average density, homogeneity, and texture. This step reduces the pictorial information to a set of descriptors that have meaning in the diagnostic process.[5] The application of such operations can help the dentist make better clinical treatment decisions.

Image Compression

The purpose of image compression is to reduce the size of digital image files for storage or transmission.. There are many ways to reduce the size of an image file; generally, they can be classified as loss less (reversible) or lossy (irreversible).

Lossless image compression (also called image coding) is used when the exact data of the original image need to be preserved. The compression rate for lossless compression is usually around 1:2.[4]

Lossy compression algorithms have been developed to achieve higher levels of compression while retaining subjective image quality.

Image Synthesis

With the integration of imaging and computer technology, imaging modalities have emerged that enable clinicians to synthesize new images based on image data acquired from multiple projections. The main purpose of these modalities is to access information about the object of interest in three dimensions. CT, MR imaging, and positron emission tomography scanners are among the most well-known and sophisticated image synthesis modalities for medical and maxillofacial imaging. Because of limited image resolution and relatively high radiation dose and cost, the application of these modalities for dental purposes is often not justified.

Tomosynthesis

Circular tomosynthesis has been described as a technique filling the continuum between transmission radiography and CT. The principle of tomosynthesis is based on selective focusing of an arbitrary slice through the object by shifting and adding a set of basis projections. The basis projections are conventional transmission radiographs of the object taken from different angles with the x-ray focus moving in a fixed plane. Based on a discrete set of basis projections, any slice through the object can be generated.

Tuned - Aperture Computed Tomography

By using properties of the object itself or its relationship to the detector, it was feasible to determine the projection geometry retrospectively. This development essentially marked the transition from tomosynthesis to tuned-aperture computed tomography[6],[7].

In a simplified version of this method, requiring a fixed position of the detector relative to the patient and a relatively large source-to-object distance, a single fiduciary reference point can be used to generate TACT slices.[4] The relative flexibility in image acquisition has facilitated the application of TACT in dental radiography.[8]

Computed Tomography Applications For Dentistry

In the 25 years since the first clinical applications of computed tomography (CT) were realized, technologic changes have occurred that allow an imaging system that required almost 5 minutes to image one slice of tissue in 1972 to generate functional, real-time imaging studies immediately. CT combines thin-section imaging or tomography with electronic image acquisition and computerized image generation. As more dentists have begun to use CT, the dental applications for it have increased.

History Of Computed Tomography Development

The first-generation CT scanner was the Mark I (EMI, London, England), the scanner placed at the Atkinson Morley Hospital. It used a pencil beam of radiation and two sodium iodide detectors. The unit was capable of acquiring two slices simultaneously. The Mark I could be used only to image the head. The patient's head was suspended in the center of the gantry using a water-filled pillow. The image matrix was 80 X 80 with a 3-mm pixel size.

The second-generation scanners used a 100 fan beam as the radiation source and an array of 8 to 30 detectors. The larger beam and increased number of detectors allowed scan times to be significantly decreased. The fastest second generation scanners could acquire a slice in 18 seconds. These scanners incorporated a 320 X 320 matrix with much smaller pixel size. The image resolution improved. The time needed to acquire a CT scan was limited by the time it took for the radiation source to gain the appropriate speed for each slice.

The third-generation or rotate-rotate CT scanner eliminated the need to translate the radiation source and the time lost in having the source achieve its appropriate rotational speed. A fan-shaped radiation source slightly larger than that used in the second-generation scanners was used, and the number of detectors was significantly increased. The detectors were arranged in a curvilinear fashion to diminish geometric distortion. The ring artifact and demand on the x-ray tube were major issues with this generation and these were addressed in the fourth-generation CT scanners.

The fourth-generation or rotate-fixed CT scanner uses a continuous circular array and consequently requires no movement of the detector array. The principal advantage of the fourth generation scanners is that each detector is activated less frequently than the third-generation detectors, and more time is allowed to access the information in each detector and prepare it for the next scan. Scatter and increased patient dose are the major disadvantages of fourth-generation scanners.

The problem of scatter has been addressed with additional collimation of the beam and shielding of the detectors. A typical CT slice can be acquired in 1 second.[6] Faster scans were not possible with any of the preceding generations of scanners because of the use of a single radiation source.

Spiral CT uses continuous patient and x-ray source motion to decrease scan times. A new term associated with spiral CT is pitch. Pitch describes the relationship of the speed of patient movement with the rotation of the x-ray source. The higher the pitch, the faster the scan. Higher pitch values, however, produce images with missing information which can be calculated through software calculations and are subject to false-positive or false-negative findings.[6] One of the technical difficulties associated with spiral CT has been in the area of image reconstruction. The information captured in one pass is no longer a slice but rather a section of a helix. As more familiarity has been gained with this type of scanner, the difficulties in image construction have diminished.

Another alternate configuration is electron-beam CT. The x-ray source consists of multiple tungsten targets arranged throughout the gantry. For image acquisition, a focused electron beam circles the gantry and produces an essentially continuous x-ray beam. This configuration greatly diminishes the heat generated in a single x-ray tube and allows for more rapid scans. Scan times of less than 100 ms have been reported. These rapid scan times have made it possible for CT to be used in functional studies rather than just static studies.

Computed Tomography System Components

There are many different system configurations for CT scanners, but they all have the same basic components-the gantry, the computer, and the operating console. [9],

Gantry

The gantry consists of the detector array, the x-ray source or tube, and the patient support couch.

X-Ray Source

The x-ray source for most of the currently available CT scanners consists of an x-ray generator and an x-ray tube. X-Ray beam is collimated at two levels: prepatient and postpatient. Coordination of the prepatient and postpatient collimators determines the thickness of the slice.

Patient Support Couch

The patient support couch provides a way to stabilize the position of a patient during a CT scan. The patient couch moves continuously in a spiral CT scan, which permits much shorter scan times but requires more accuracy in patient positioning.

Computer

The rapidity of image capture and larger matrix size (512 X 512) necessitate the use of high-speed computers. The computers use an array processor to permit the simultaneous solution of all the equations generated during a scan. The time it takes the computer to generate a visible image after data acquisition is termed reconstruction time. Reconstruction time for a single slice is usually on the order of 1 second. These computers can constitute one third the cost of a CT scanner.

Image Acquisition

CT images are acquired in the axial plane. These images are taken in succession and are generally referred to as slices. The information from multiple slices can be reformated to produce images in the coronal, sagittal, or panoramic orientation. Three-dimensional images can also be generated from these data. The typical image matrix for most CT scanners is 512 X 512, or 262,144 pixels.[10] Pixels are two dimensional entities. When the thickness of a CT slice is applied to the matrix, the individual elements are designated as volume elements or voxels. The volume of tissue represented in a voxel can be calculated by multiplying the pixel dimensions by the slice width[11]. The advantage of CT is that each slice can be viewed individually and that the superimposition of structures can be minimized. This manipulation is accomplished by adjusting the field of view (FOV) or diameter of the reconstructed Image.[12]

CT Numbers Or Hounsfield Units

The numeric data in each pixel are called a CT number or Hounsfield unit. The CT number corresponds to the linear attenuation coefficient of a particular tissue at a designated kilovoltage. CT numbers generally range between -1000 and + 1000. By convention, water is assigned a CT number of 0. Air is usually assigned a CT number of -1000 and cortical bone, + 1000.

Image Reconstruction

Image reconstruction is a complex procedure that is performed by the computer system of the CT scanner. Several different algorithms are used to reconstruct CT images-back-projection, iterative reconstruction, and analytic reconstructions.

Image Enhancements

One of the advantages of CT imaging is that the image can be electronically processed without altering the original image. Additionally, images can be viewed in different orientations and with different density parameters. All CT images are acquired from an axial orientation. The data from the original image can be reconstructed to produce an image in a sagittal or coronal plane. A three-dimensional rendering of a structure or image can also be reconstructed from the original data

Patient Exposure To Radiation

CT has always been considered a high radiation dose technique. Several parameters effect the patient dose, including the area being imaged, the number of slices, the thickness of the slice, and the kilovolt peak. The effective dose has been calculated as 2 to 4 mSv for a head scan and 5 to 15 mSv for a body scan.[11]

CT has provided the technology to improve greatly the pretreatment assessment of intraosseous implant sites. CT makes it possible to reformat the original data into a number of new configurations. These data can be reformated to display information in a panoramic view as well as in a cross-sectional view. Radiopaque markers can be placed over the intended implant site so that the appropriate slice can be indexed. Care must be taken to use a marker that is not so radiodense that it produces image artifacts that obscure the area of interest.

Three-dimensional Computed Tomography Imaging In Dentistry

The development of spiral/helical computed tomography (CT) scanning in combination with three-dimensional rendering techniques produces high-quality three-dimensional CT (3-D CT) images that can be used for diagnostic imaging and biomedical research in dentistry. 3-D CT imaging has been used for the diagnosis and treatment planning of various lesions

In CT scans of the maxillofacial region, a high-resolution power is needed because the area of interest is specific. Spiral/helical CT scanners generate adequate image data to create three-dimensional images with less scanning time and less radiation compared with conventional CT scans. These newer machines feature a continuous scanner rotation and object transport (tabletop movement). Most of the current three-dimensional rendering software requires the continuous data sets of multiple two-dimensional axial CT slices to generate three-dimensional images.

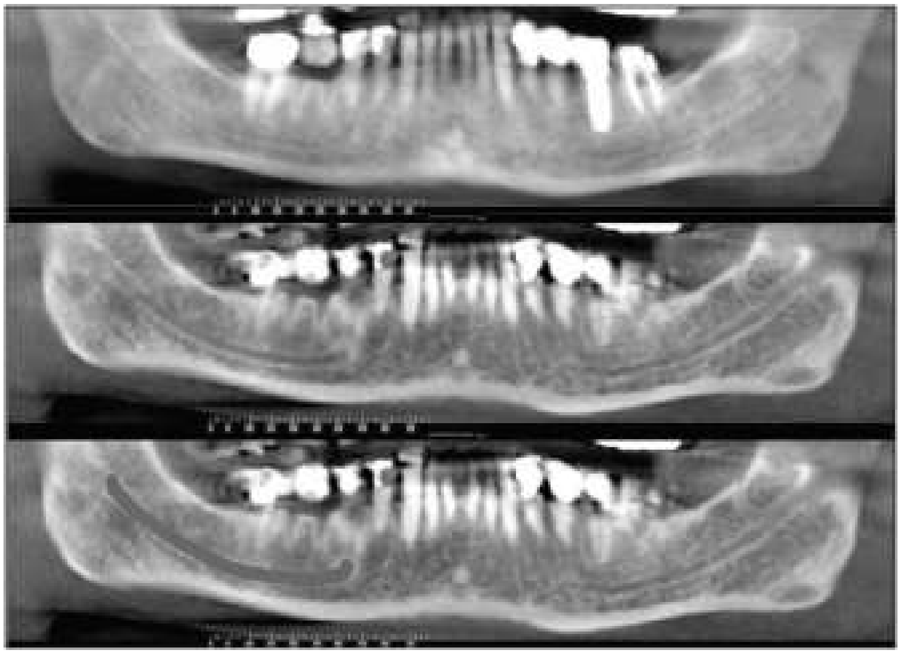
Cone-beam CT

The ability to synthesize 3-D views from multiple projections is not limited to fan-beam geometry as used in medical CT units. Cone-beam geometry, like in conventional dental X-ray units, can also be used to generate 3-D CT images. With cone-beam geometry a patient volume can be scanned in a single rotation. Together with fast area image receptors, such as image intensifiers or flat panel detectors, a much lower patient dose is achieved than with conventional CT for a similar size volume. The simplified design of cone-beam CT units also allows for a considerable cost savings relative to medical CT units. One of the main drawbacks of cone-beam CT (CBCT) is the increased effect of scatter radiation on image quality. Scatter radiation reduces contrast and limits the imaging of soft tissues. Therefore, CBCT is mainly indicated for imaging hard tissues.

Already, CBCT units have been developed specifically for oral and maxillofacial imaging[13],[14],[15]. For example, the NewTom QR-DVT-9000 (QR-NIM s.r.l., Verona, Italy) is a large area CBCT unit and is employed by several institutions and practices throughout Europe and the United States. Initial dose estimates for this unit indicate that a full scan of the mandible and the maxilla generates an effective dose approximately 3–6 times that of a single panoramic radiograph[16]. Main applications of this unit include implant site evaluation, orthodontics, oral surgery and temporomandibular joint imaging..

Digital Image

Normal IOPA



CBCT

Investigations regarding the usefulness of CBCT for periodontal applications are in progress.

Local CT

Local CT (LCT) is a form of CBCT. LCT distinguishes itself by using a small-field high-resolution detector to generate a limited high-resolution 3-D volume. The field or volume size varies, but is generally comparable to the dimensions of conventional intraoral radiographs. LCT generates exquisite image detail in three dimensions while retaining the advantages of reduced patient dose and reduced cost. This makes LCT particularly suited for dental applications.[17] This technology is still relatively new and commercial availability is limited. The characteristics of LCT make it a very promising modality for imaging the alveolar bone, both for the assessment of bone destruction and for implant site assessment.

Optical Coherence Tomography

Optical Coherence Tomography (OCT) generates cross-sectional images of biological tissues using a near-infrared light source. The light is able to penetrate into the tissue without biologically harmful effects. Differences in the reflection of the light are used to generate a signal that corresponds to the morphology and composition of the underlying tissues. A prototype OCT system was developed and tested in vitro as well as in vivo[18],[19]. The feasibility of its clinical use was demonstrated by capturing high-resolution images of oral structures, including soft tissue and hard tissue boundaries of the periodontium. While it is yet too early to judge the potential success of OCT as a routine clinical tool, the initial results warrant keeping an eye on further developments of this technology.

Denta Scan

Dental CT formatting software programme which reformats axial CT images of jaw into panoramic and paraxial images and provide programmed reformation, organization and display of imaging study. It has revolutionized the oromaxillofacial imaging and is an excellent imaging modality. Radiologist has to indicate the curvature of mandibular or maxillary arch and computer is programmed to generate referenced cross sectional and panoramic images of the alveolus along with 3-D images of the arch[20].

Indications include Pre operative evaluation of implants, Post implantation complications, Assess inflammatory diseases like apical periodontitis, sclerosing osteitis, periosteal reaction, reactive sinusitis; Tumors and cysts; Oro antral fistulas: exact size and location; Root fractures; Locate foreign bodies in jaws

It has the advantages of minimum additional cost; Low radiation dose; Multiplaner reformation; Eliminate streak artifacts; Exact information about alveolar bone dimensions and Location of mandibular canal and maxillary sinus

In implant imaging, it helps in measuring Bone quantity: Height and bucco lingual dimension of ridge at implant site; Bone volume: Extent of bone resorption; Bone quality and precise location of vital structures.

Summary and Conclusion

The adoption of advances in the radiographic modality of the future, when based on sound scientific evidence, has the potential to transform the way we visualize the periodontal tissues. Digital image standardization, subtraction radiography, 3-D imaging and quantitative image analysis are already a reality. There is little doubt that periodontists of the future will be using more advanced imaging modalities, either directly as a chairside procedure, or indirectly through the services of an oral and maxillofacial radiologist.

Future Trends:

From Roentgen's discovery of x-rays in 1895 until the early 1970s, radiographs were planar, 2D views of anatomy. Thanks to the efforts of early pioneers, including Godfrey Hounsfield, computed tomography (CT) became a reality. It was considered a major leap in diagnostic radiology. Over the past few decades, there have been similar diagnostic and treatment paradigm shifts in dentistry, including the advent of high-speed handpieces, root-form implants, and digital radiography, but perhaps the most dramatic is the rapid adaptation of the cone beam CT (CBCT).With all these advantages, the application of teleradiology should be made a routine daytime practice to enhance the pace of communication. Major advances in ability to capture medical information in digital form, telecommunications and computer systems should accelerate the ability to apply teleradiographic methods in a practical and affordable manner.

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