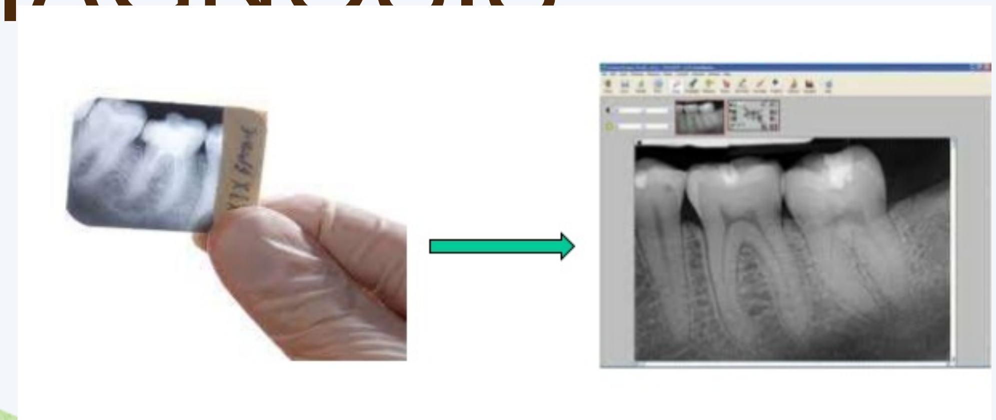
DIGITAL RADIOGRAPHIC DIAGNOSIS



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TERMINOLOGIES

- **Brightness**: digital equivalent to density or overall degree of image darkening.
- **Dynamic range**: Numerical range of pixels or shades of grey that can be represented.
- **Linearity**: Direct relation between exposure and image density.
- **Contrast resolution**: Ability to differentiate small differences in density as displayed on image.
- **Spatial frequency**: measure of resolution expressed in line pairs per millimeter.

Digital Imaging

- Digital imaging was first known to dentistry in 1984 when RVG was invented by **Dr Franscis Mouyens.**
- In the early days, digital radiograph was achieved by digitizing the film by camera or scanner which led to considerable loss of image properties but today we have digital imaging.
- digital imaging can be :

direct-charged couple device (CCD) type

Indirect-photostimulable phosphor(PSP) type

Intraoral receptor comparisons of digital imaging

FEATURE	FILM	CCD	PSP
Radiation dose	high	low	Low
Generation of image	chemical	computer	Scanner , computer
Image viewing	delayed	instant	Instant
Resolution	16-20 IP/mm	8-10 IP/mm	6-8IP/mm
Construction	Thin Flexible	Thick, rigid	Thin ,flexible
Lifespan	single	reusable	Reusable after erasure
Infection control	Drop out	Barrier	Barrier
Image enhancement	fixed	Multiple Operations	Multiple operations
storage	Patient Record	CPU,CD	CPU,CD

Direct digital imaging

Pixel consists of a small electron well into which xray light is deposited upon exposure

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Fiberoptically coupled sensors utilize scientillation screen couples to CCD which stores the image

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Data acquired by sensor is communicated to computer in analog form

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Data transfrred into numerical data based on binary digit system

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Image is reproduced on screen

Indirect Digital Imaging

Image is captured on phosphor plate as analog signal

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Converted to digital format when the plate is processed

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PSP consists of base coated with BaFBr:Eu that converts xray into stored energy

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Energy is released as blue fluorescent light on scanning

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This light is then captured and intensified by photomultiplier tube

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Converted to digital area

Advantages of Digital Imaging

- Digital image is dynamic image, it's contrast, density can be changed
- The digital receptors have wider latitude so in principle should reduce the number of retakes
- PSP is more flexible and cordless ,so easy to place
- Only 5-50% dose needed, definitive exposure reduction
- Elimination of processing chemicals
- Working time reduced by instant image production
- Patient education
- Easy storage
- Safest method with reduced exposure

Disadvantages of Digital Imaging

- In case of CCD, increased rigidity and thickness of sensor
- Unknown lifespan of sensor
- High cost
- Care of usage
- Inability to perform complete infection control

RADIOVISIOGRAPHY

- Invented by dr. Franscis Mouyens in 1981 and introduced commercially in 1989
- Original system was useful in diagnosis of occlusal and approximal caries only whereas the periodontal assessments made possible recently with invention of 2nd generation system
- Basically four components:

1)X- ray set with electronic timer

2)An intraoral sensor

3) Display Processing Unit

4)Printer

- **Original System, Mark 1**: based on digital hardware without microprocessor
- **Initial 2nd generation, Mark 2** :based on a 32-bit software driven central processing unit

- Failed to achieve abilities of Mark 1 system

- Lacked the memory to use fully the resolving power of the sensor chip, and the number of grey levels which could be displayed on monitor screen was only 64 compared to 256 in Mark 1 model.

- **Second Mark 2**: improvements in initial Mark 2 resulted in the second Mark 2

-Available in some countries as mobile unit

Components Of RVG

1)X-Ray set

- Conventional x-ray tube with generation operating at 70 kvp for use with RVG system
- It is connected to a microprocessor controlled timer which allows exposure time of 0.02 sec

2)Intraoral Sensor:

- houses a rare-earth intensifying

screen which is optically coupled

to an array of CCD

- in Mark 2 system both normal

and zoom high resolution was available

- Updated sensor supplied in mark 3 has a 25% larger sensetive area & less thickness by 16%
- waterproof sensor has been developed which can undergo cold sterilization procedures

3)Display Processing unit

- After radiation exposure,analog signal obtained is stored in this unit and converted pixel by pixel into discrete grey levels
- Allows upto 256 levels of grey to be achieved
- In the Mark 2 system more flexible digital image processing was available along with the facility for storing the image databy transmission to a microcomputer
- The mark 3 model uses a color

VGA monitor

4)Video Printer:

- Original video printer used with mark 1 was manufactured by sony
- A Dry Silver Imager was used in Mark 2
- The digital graphic printer used with mark 3 system

- **Features of RVG**:

1)Image enhancement

- The grey window effect/x-function

allows the operator to select & expand on a specific 60 levels of grey from 256 available, aid in diagnosis of accessory canals

- Image can be electronically enhanced by smoothing, edge enhancement and edge detection.
- Millimeter grid has been added in mark 3 system,which may prove as an additional aid when positioning instrument during root canal therapy

2)Radiation Dose:

-Horner,Walker determined the radiation dose on the RVG setting on the Mark 1 system to be 23% of that required for D-film or 41% of the doses required for exposure of E film

3)Collimation:

-incorporation of rectangular collimation further reduces radiation dose.

GENERATIONS OF RVG:

The First Generation:

- introduced in Europe in 1987.
- provided a basic grey scale image
- display without image processing capabilities.

The Second Generation:

- included software driven central processing unit. Due to

  insufficient memory for storage and display of full resolution images, a fourto-one pixel averaging compression was utilized for display.
- the display reduced the internal 8-bit

  capacity to 6-bit.

The Third Generation:

- incorporated modifications which increased the sensitivity and dose dynamics of the sensor. In this model, the sensor was sealed and colour coded to indicate the X-ray sensitive side.
- also provided image enhancement features including gradient contrast adjustment and black/white reversal, but added a steep gradient enhancement with only 8 grey levels displayed and the choice of full resolution image acquisition (high resolution zoom or ZHR).
- Only four 'normal' images or one ZHR image could be held in the RVG buffer without storage in an attached computer.
- Images were therefore printed using a thermal printer and archived as analogue 'hard copies‘.

The Fourth Generation:

- has a more compact and ergonomic keyboard, a super VGA (video graphic array) colour monitor, a more powerful CPU and a more streamlined and visually presentable overall appearance.
- Twenty images can be stored in the buffer without downloading to the storage device.
- It had an option of automatic exposure compensation (AEC) , which compensated for exposure errors by stretching the pixel value range to increase the contrast of structures within the images.
- **The Fifth Generation**:
- RVG-ui and the Dexis are the examples of this generation. The RVG-ui is a solidstate system for dental x-ray imaging combining a CCD of small pixel size (19.5μ) with a caesium iodide scintillator.

- It features two sizes of sensor with receptive areas that approach the size of No. 1 and No. 2 periapical x-ray films.
- The spatial resolution of the RVGui exceeds 20 lp/mm, rivaling conventional intra-oral x-ray film when the latter is optimally exposed and processed.

The Sixth Generation:

- combines the best attributes of CCD and CMOS

(Complementary Metal Oxide Semiconductor) sensors in a single component, allowing for the capture of high-quality radiographs at exceptional speed.

- features excellent contrast perceptibility to support high standards of diagnostics and patient care

- **The Seventh Generation**:
- have rounded corners which help make the sensor more comfortable for patients.
- introduced a new size 0 sensor for pediatric examinations and shock absorbing material protects the sensor from damage.
- It's fiber optic technology provides high resolution digital images enabling clinicians to make swift and accurate diagnoses.
- The system also employs a sensor remote control, allowing clinicians to capture and display images chair-side in less than two seconds

The Digora system

- The Digora image plate system is an alternative, with fundamentally different digital image acquisition from that of CCD systems
- Introduced in 1994 and provides two sizes of imaging plates comparable with the size = 0 and = 2 film. A single plate can be scanned for approximately 30Sec.
- In 1997, the Den Optix system was introduced. The system has five sizes of imaging plates which are mounted in a carousel which can hold up to 29 imaging plates for scanning

- With the Digora system the anatomic area displayed is almost the same as that shown in modern film-based technology.

. Read out of the image plate takes less than 30 seconds,during which the image gradually appears on the computer monitor

- The system works in a Microsoft Windows environment, which simplifies all operating procedures.
- High quality image which can be enhanced
- Different type of measurements such as measurements of linear distances and angles are possible
- Display of histograms of distribution og gray levels in chosen area is possible

ADVANCEMENTS IN DENTAL IMAGING

❖ Magnetic Resonance Systems

- Paul lauterbur described 1st magnetic resonance image In 1973. MRI developed for clinical use in 1980.
- Patient is placed inside a large magnet. This magnetic field causes the nuclei of many atoms ,particularly hydrogen to align with the magnetic field.
- The scanner redirects the radiofrequency pulse (RF) into the patient, causing hydogen nuclei to resonate.
- When RF pulse is turned off the stored energy is released from body and detected as a signal in a coil in the scanner.
- This signal is used to construct the magnetic resonance image ,which is a map of distibution of hydrogens.

- **Advantages:**
- Noninvasive , No ionizing radiation involved in MRI
- High quality images of soft tissue in any imaging plane
- Region of body imaged with MRI is controlled with gradient coil, direct multiplanar imaging is possible without reorienting the patient.
- Superior sensitivity in detecting small lesions and More accuracy in staging the lesion and narrowing the diagnostic possibilities.
- **Disadvantages:**
- Relatively long imaging times
- Pontial hazard imposed by presence of ferromagnetic metals in the vicinity of the imaging magnet. various metals can either distort the image or may move in the strong magnetic field, injuring the patient (e.g. cardiac pacemakers ,cerebral aneurysmal clips)

- **Clinical Application**:
- Evaluation of soft tissue conditions
- For soft tissue disease especially neoplams involving soft tissue such as toungue,cheek,neck
- To determine malignant involvement of lymph nodes
- To determine perineural invasion by malignaant neoplasia

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Nuclear Imaging

- Film radiography,CT,MRIS record macroscopic anatomis change but in some diseases abnormal biochemical change occur without any anatomical change.
- RadioNuclide imaging ,a form of functional imaging provides a means for assessing such physiologic change.
- Radionuclide imaging uses radioactive atoms or molecules that emit gamma rays.
- After the radionuclides are administered,they distribute in the body according to their chemical properties.
- The gamma-scientillation camera detects the gamma rays and forms the planar images, showing the locations ofmradionuclides in the body.

USES:

- for the visualization of physiologic alterations in bone metabolism and blood flow rate.
- To investigate abnormal bone metabolism activity e.g. for assessing growth activity In cases of condylar hyperplasia and presence of metastatic lesions.
- The high sensitivity of nuclear bone imaging makes it valuable in the initial detection of subtle bone fractures that are not readily apparent on standard radiographs.
- for assessment of facial skeletal growth

❖ Positron emission tomography (PET) , a test with a good predictive value for identifying recurrent malignancies in the head and neck when used in conjunction with CT.

Computed Tomography

- J Radon, 1917 was the first person to lay the foundation forsuch an imaging
- in 1972, the first clinical computedtomography X-ray unit was developed by GN Hounsfield
- Computed tomography (CT) uses X-rays to portray a cross-sectional image of an object without superimpositions.
- The CT scanner makes multiple projections of an object,radiation detectors measure the object’s X-ray attenuation at each of these projections, and a computer reconstructs the attenuation data to produce a cross-sectional image, or “slice”, of the object.

Applications of Computed Tomography

- useful for the study of anatomic or pathologic structure.
- diagnosis, treatment planning, and postoperative follow-up of patients with craniofacial anomalies.
- noninvasive estimation of bone mass
- study of salivary gland disease
- assessment of traumatic injuries to the skeleton.
- in dental implant treatment planning
- **Disadvantages of Computed Tomography**
- High radiation dose relative to that of plain-film radiography
- High cost
- Relatively long time of image acquisition.

Spiral CT

- Spiral Computed Tomography (SCT) or volume acquisition CT employs simultaneous patient translation through the X-ray source with continuous rotation of the source detector assembly,
- SCT acquires raw projection data with a spiral-sampling locus in a relatively short period and without any additional scanning time
- these data can be viewed as conventional transaxial images, such as multiplanar reconstructions, or as three dimensional reconstructions.
- With SCT, it is possible to reconstruct overlapping structures at arbitrary intervals and thus the ability to resolve small objects is increased.

Cone-Beam CT Technology

- Cone beam computed tomography (or CBCT) is an imaging technique consisting of X-ray computed tomography where the X-rays are divergent, forming a cone
- **Attilio Tacconi, Piero Mozzo, Daniele Godi and Giordano Ronca are the** pioneers of this technology.
- CBCT allows the creation in "real time" of images not only in the axial plane but also 2-dimensional (2D) images in the coronal, sagittal and even oblique or curved image planes — a process referred to asmultiplanar reformation (MPR)
- CBCT data are amenable to reformation in a volume, rather than a slice,providing 3-dimensional (3D) information.

Advantages of CBCT

- for imaging the craniofacial area.
- provides clear images of highly contrasted structures and is extremely useful for evaluating bone.
- X-ray beam limitation as the effective patient dose to approximately that of a film-based periapical survey of the dentition.
- Because CBCT acquires all basis images in a single rotation, scan time is rapid (10–70 seconds).
- CBCT images can result in a low level of metal artifact, particularly in secondary reconstructions designed for viewing the teeth and jaws.

- Reconstruction of CBCT data is performed natively by a personal computer. In addition, software can be made available which provides the clinician with the opportunity to use chair-side image display, real-time analysis.

Disadvantages:

- Increased susceptibility to movement artifacts.
- Lack of appropriate bone density determination.
- Dental CBCT systems do not employ a standardized system for scaling the grey levels that represent the reconstructed density values and, as such, they are arbitrary and do not allow for assessment of bone quality.

Uses of CBCT

- Implantolgy
  - To assess osseointegration
  - To determine quality of bone
  - To check the relation of implant
  - During surgical guidance
- Maxillofacial surgery
  - To diagnose tumors, impacted teeth, fractures
  - To identify relation of teeth with nerve canals
  - Cystic lesions and delimitations
  - Traumatic injuries to teeth

- Orthodontics

– Planning of orthognathic surgery

– Cephalometric analysis

- Endodontics

-In diagnosing of periapical lesions

– Identification of canals

– Endodontic surgery

- Pediatric dentistry

– Temporomandibular Joint (TMJ) evaluation

– Evaluation of growth

– In cleft cases

- Periodontology

– Bone lesions and healing