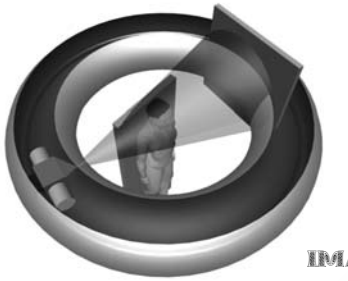
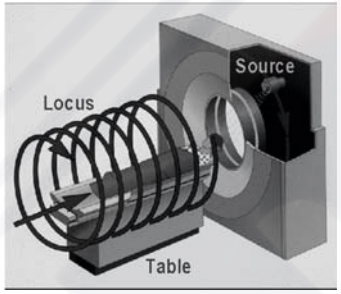
Syrian Private University
Faculty of Dentistry
Department of Oral Medicine

Computed tomography

Lecture 4



IMAD BRINJIKJI



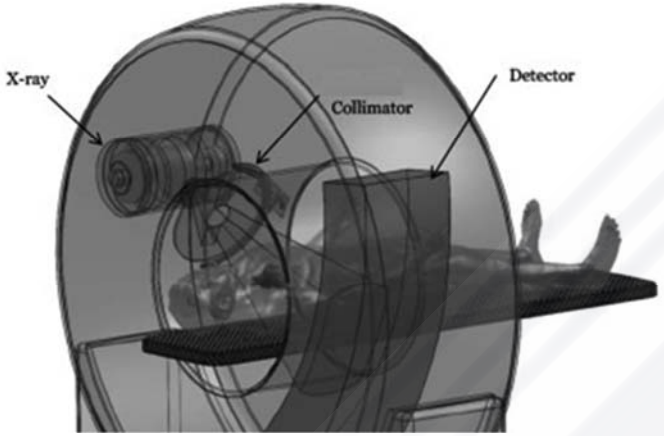
Computed Tomography (CT)

- **CT refers to numerous devices, but the same technique.**
- **For example: clinical use/ bone biopsies – central / peripheral organs…**

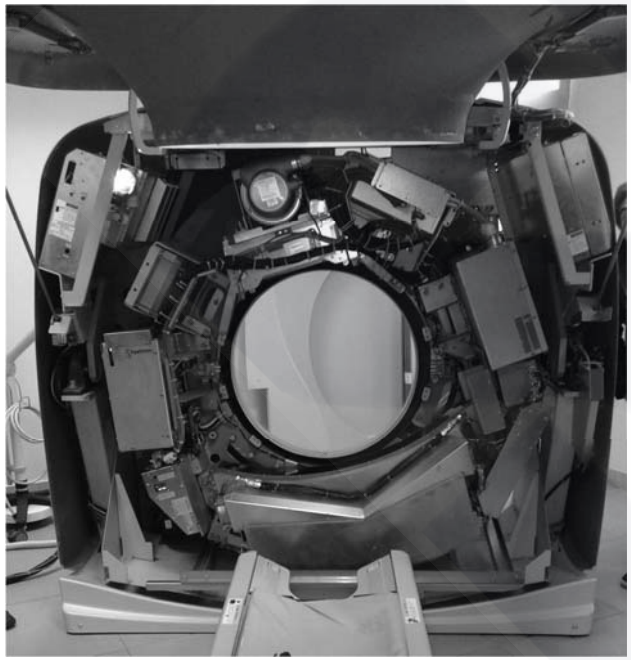
Synonyms

- **Multi-detector CT (MDCT).**
- **Multi-slice CT (MSCT).**
- Multi-detector helical (spiral) CT.
- Multi-row CT.
- Electron beam CT (especially for heart scanning).
- CT scan.
- Computed axial tomography (CAT).
- Fan-beam tomography (specially the single-slice detectors).
- Medical CT.

Main components of the MDCT



Main components of the MDCT



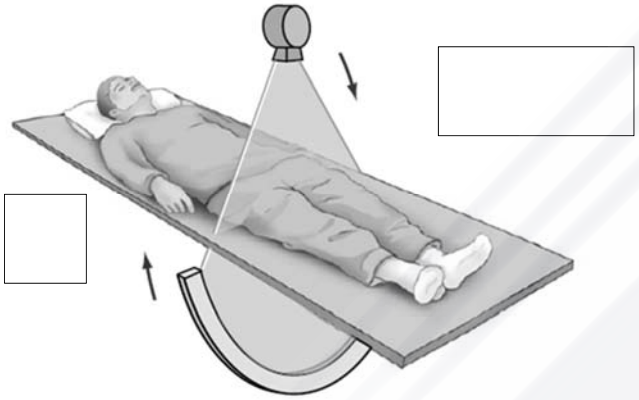
CT generations

CT has seven generations:

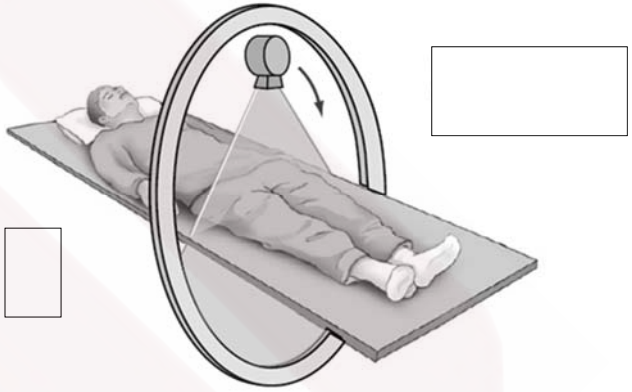
- 3rd Gen: Both the x-ray tube and the detectors rotated synchronously around the patient (wide beam angulation).

- 4th Gen: The detectors form a continuous ring around the patient.

3rd generation
Rotate-rotate

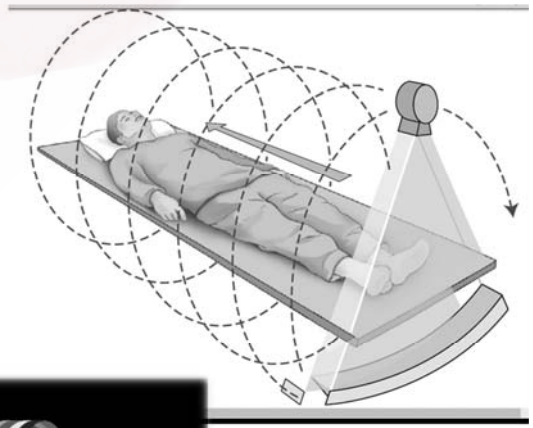


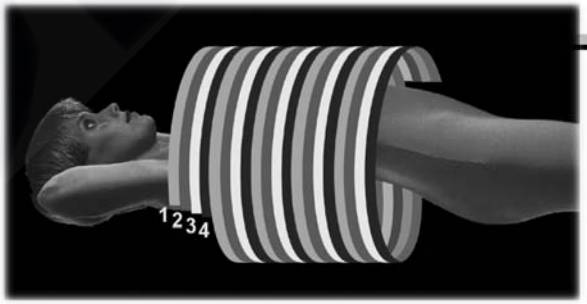
4th generation
Rotate-stationary



CT generations

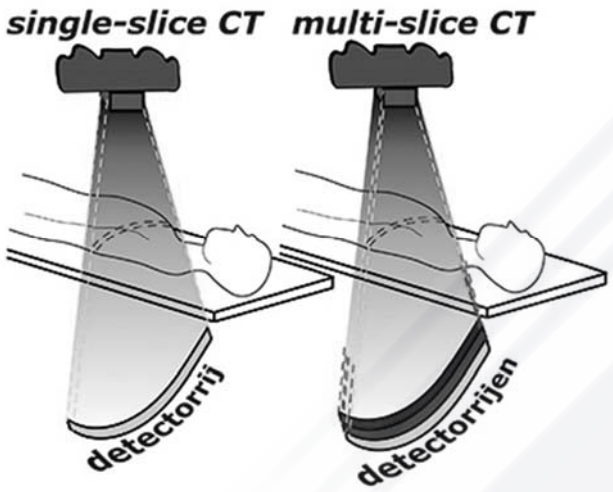
- 6th Gen: Helical (Spiral) CT.
- 7th Gen: Multidetector CT (MDCT).



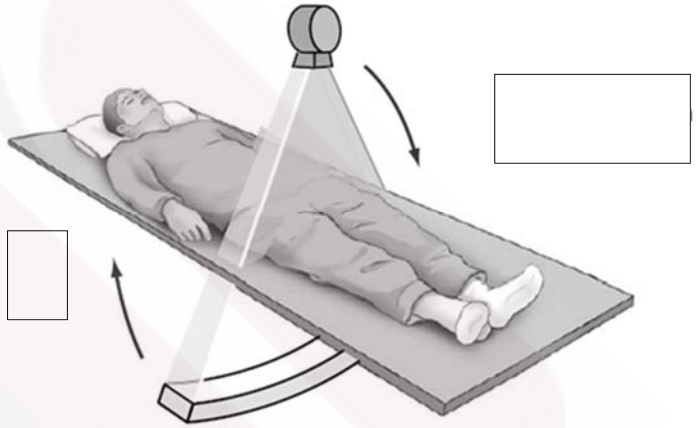


So, MDCT scanners use the helical technique with (most commonly) the 3rd gen design (X-ray-tube/detectors motion).

All CT scanners nowadays are MDCT.



MDCT



Most MDCT use the 3rd generation design.

X-ray tube

- High radiation output.
- KV (80-140), usually 120.
- mA= 200-800 (new devices offer as low as 50mA).
- High heat capacity (8M compared to 20K of dental units).
- The beam is collimated twice (pre-patient and post-patient).

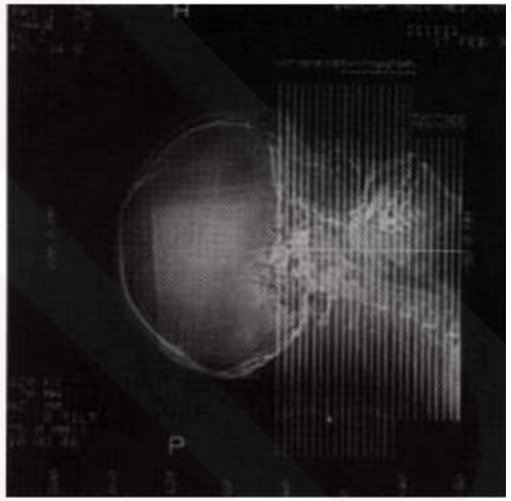
Detectors

- Two main types of detectors: Gas-filled (old)/ solid-state (rare earth elements such as Gd_2S_2O).
- Up to 4 rotation/ second: useful for scanning the heart (in 350 ms) and reducing breathing artefacts.

Scanning procedures

- Take a scout.

Scanning procedures

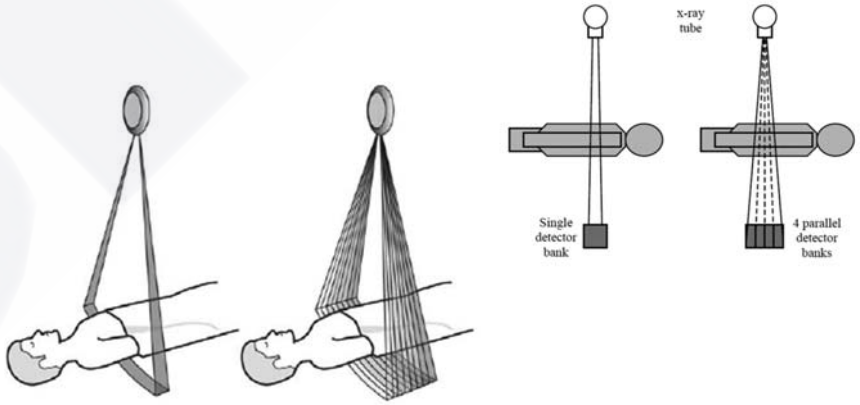


Considerations for scanning the jaws

- It is preferable to make the scan parallel to the occlusal plane (Why?).
- It is recommended to stop breathing during the scan to reduce motion artefacts.
- Smaller voxels are preferable (if the aim is to study only the hard tissues (bone/teeth), cone beam CT may be preferable.

How does image form?

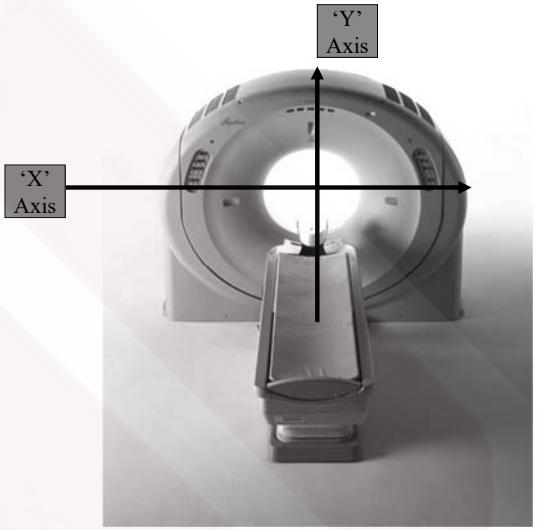
Projections → processed → construct → 3D volume data set.



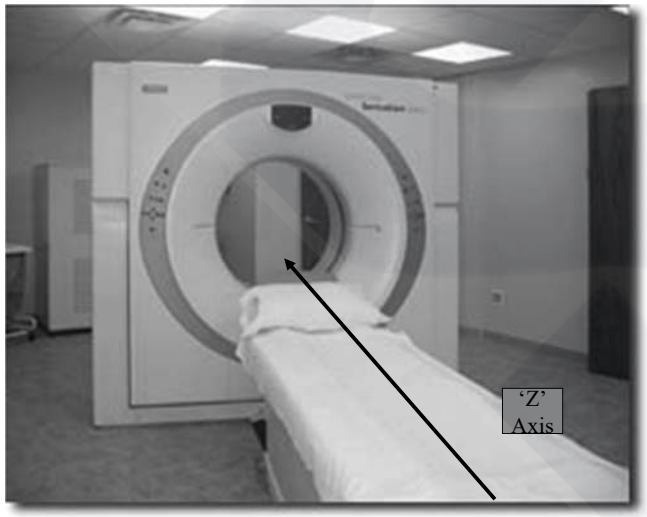
How does image form?
Image reconstruction

- CT segments the object into small cuboids (sometime the cuboid is cubic).
- Each cuboid is called **voxel (volume element).**
- CT calculates the densities of each voxel using a special algorithm.

CT 'X' axis 'Y' axis

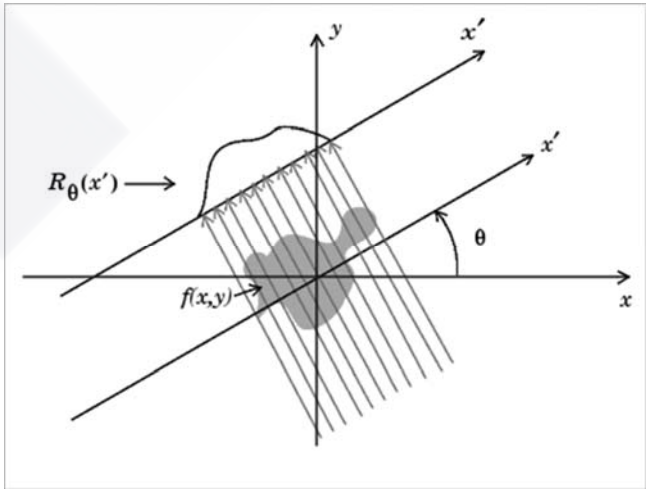


CT 'Z' Axis

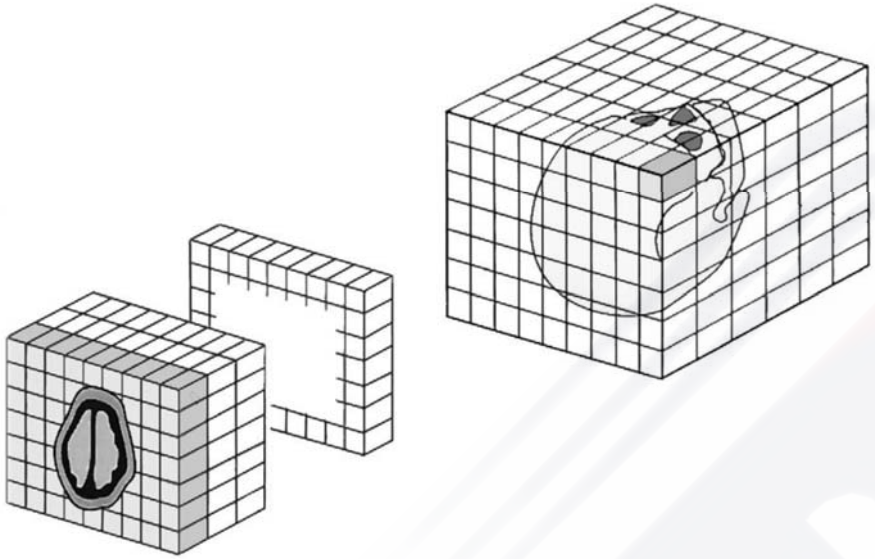


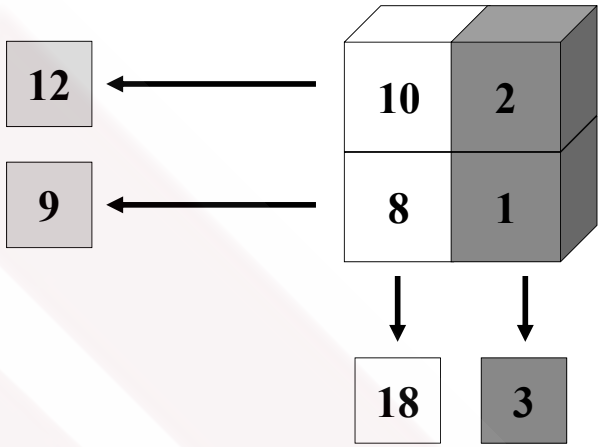
How does image form?

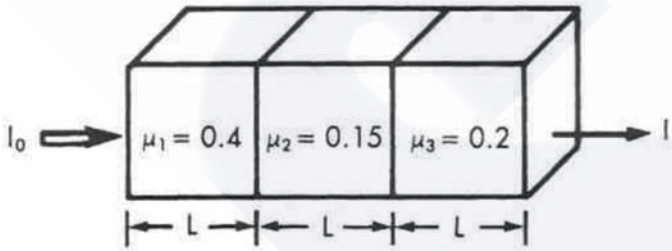
Filtered back projection

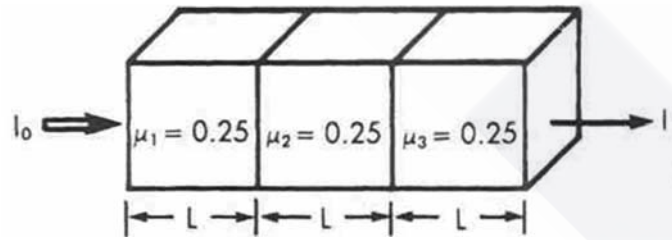


How does image form?

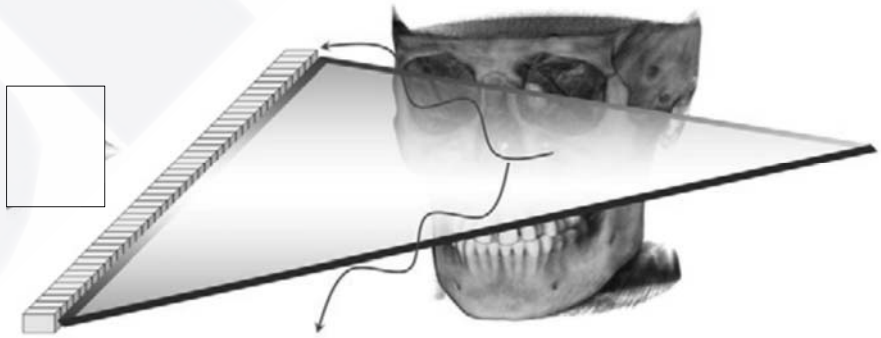








The shape of the beam and the design of the detectors reduce the collected scattered radiation.



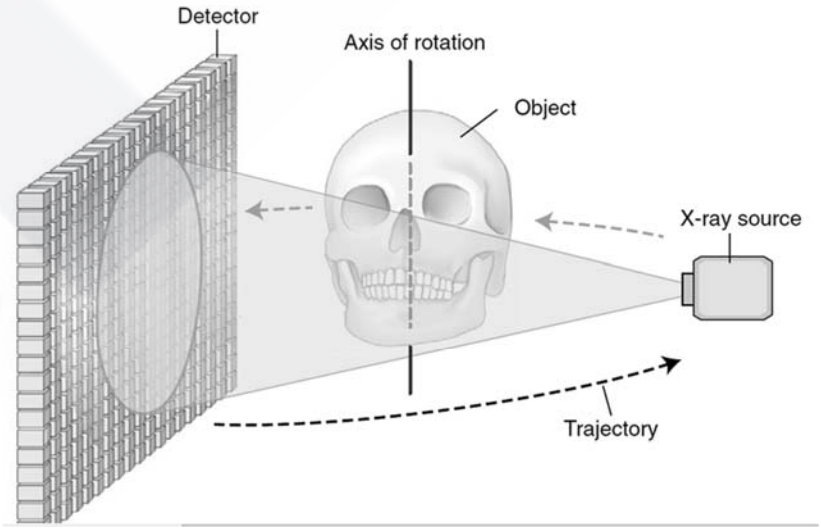
Cone beam CT

Cone beam CT

- Cone beam computed tomography (CBCT) depends on the CT technique, with slight differences.
- It uses a divergent cone-shaped or pyramid-shaped beam.
- This device was introduced in 1998 for maxillofacial imaging, as a cheaper, easy-to-access choice with a lower radiation dose than the standard CT.

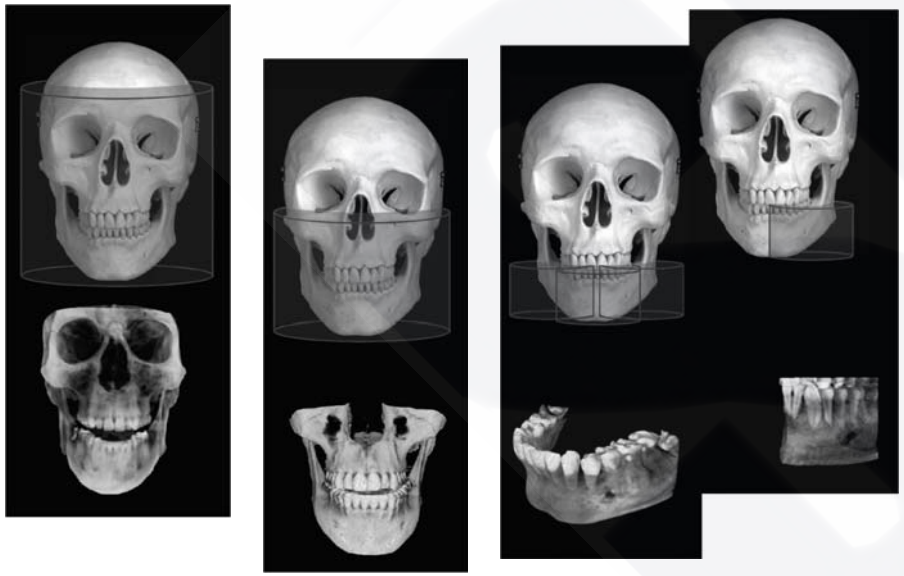
Cone beam CT

- Collect several hundreds of basis (raw) images in a single rotation (180^0 to 360^0).
- Automatic exposure control in many devices.
- The patient is also aligned so that the occlusal plane is parallel to the floor.



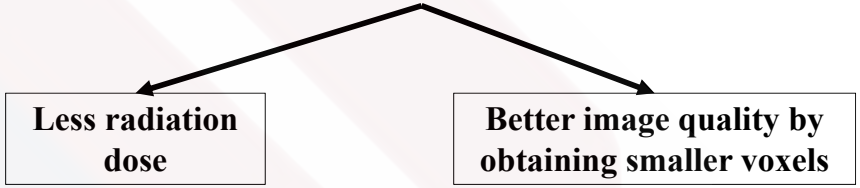
Basis (raw) images

- During the rotation, multiple sequential planar projection images are obtained while the x-ray source and detector move through an arc of 180 to 360 degrees.
- These projection images (the raw or basis images) are similar to cephalometric radiographic images except that each is slightly offset from the next.
- These raw images are used to form a 3D volume data of the head.



Scan volume (Filed of view)

- In contrast to MDCT, it is possible to choose the scan volume (field of view) in CBCT.
- **Smaller field** of view are preferable when it is enough for the diagnosis, because:



Cone beam CT

- mA= 8-20 (not exceeding 50).
- KV= 80-110.
- Rotation: full/ partial circle.
- More scattered radiation.

CBCT detectors

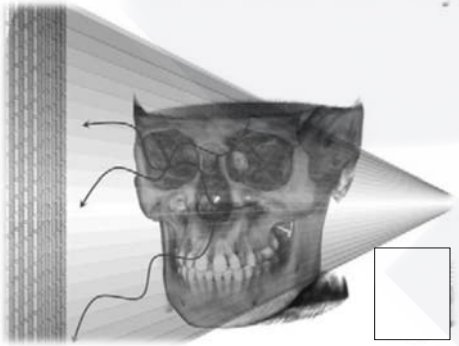
- II/CCD: Image intensifier tube/charge-coupled device combination.
- Flat panel detectors (FPDs).
- CMOS (complementary metal oxide semiconductor).

Strengths of CBCT
(generally in comparison to MDCT)

- The device is smaller in size and costs less.
- Fast acquisition.
- Smaller voxel size (up to 0.076 mm). The voxels in CBCT in general are isotropic.
- Lower patient radiation dose (in the default settings).
- CBCT: 25 to 1025 μSv/ MDCT: 430 to 1160 μSv).
- Interactive software specially designed for dentists.

Limitations of CBCT

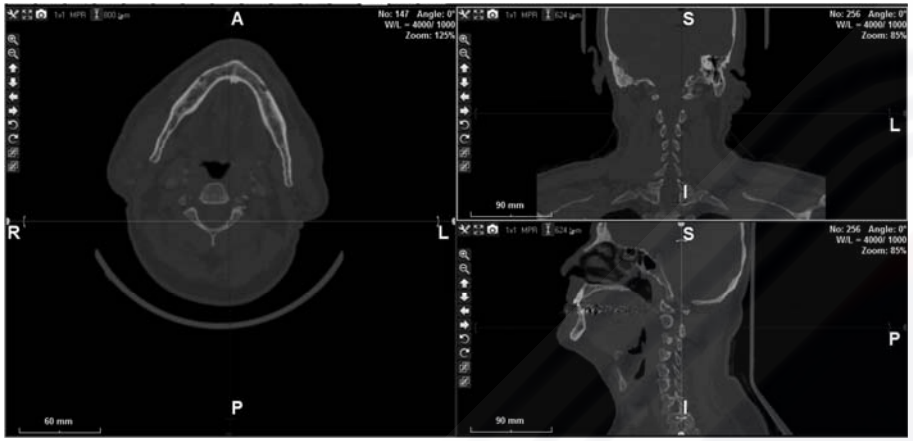
- Image noise: due to scattered radiation and electronic noise (related to detectors).

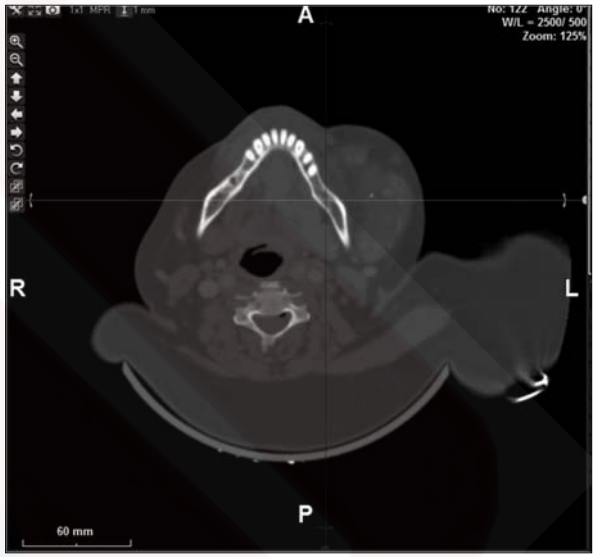


- Poor soft tissue contrast.

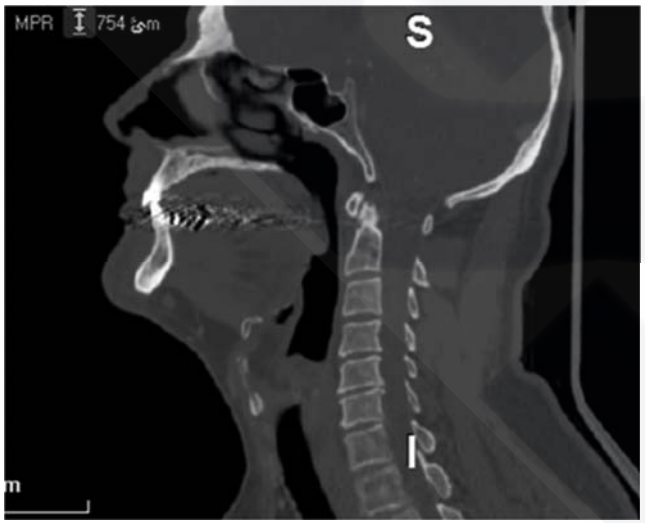
What are the resultant images in MDCT and CBCT?

Axial/ transverse

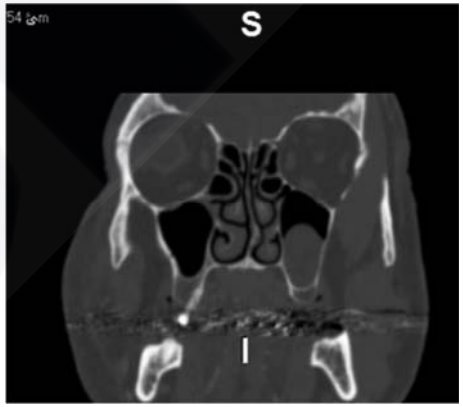


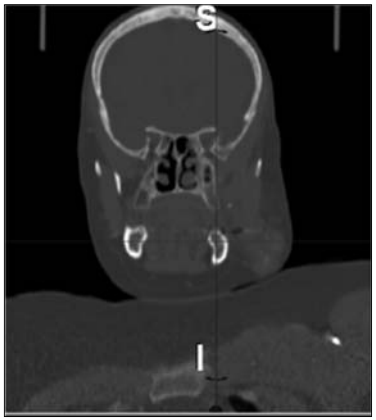


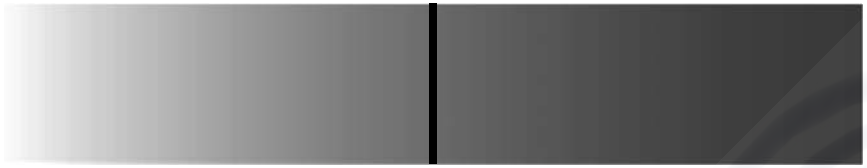
Sagittal



Coronal







+3000 **0 water** -1096

In general, there are 4096 shades of gray (from pure white to pure black) in MDCT and CBCT devices.

Bone	**400 – 1000**
Soft tissue	**40 – 80**
Water	**0**
Fat	**/-60/ - /-100/**
Air	**-1000**

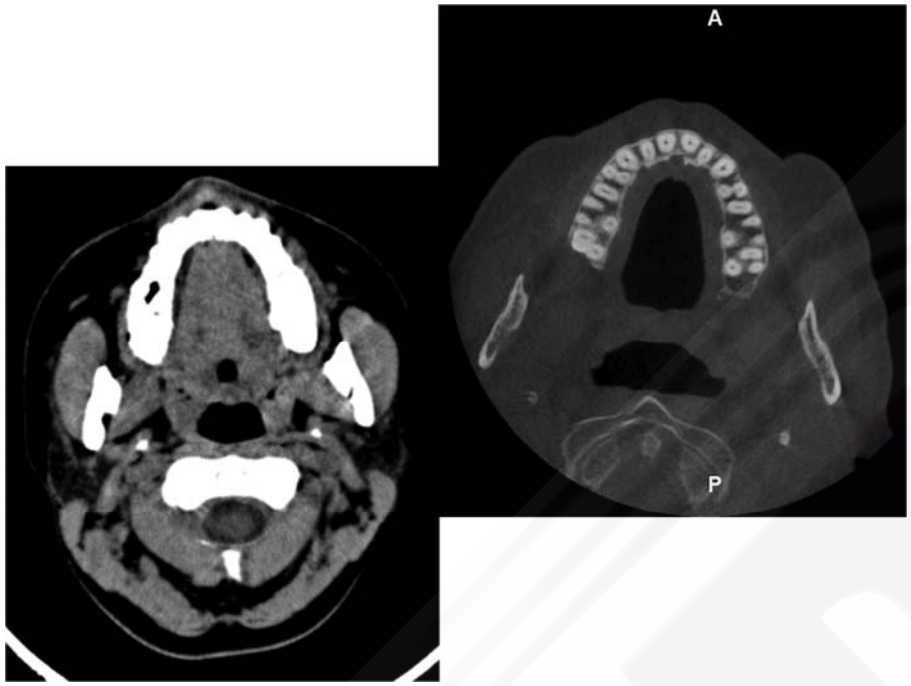
Common CT values in MDCT

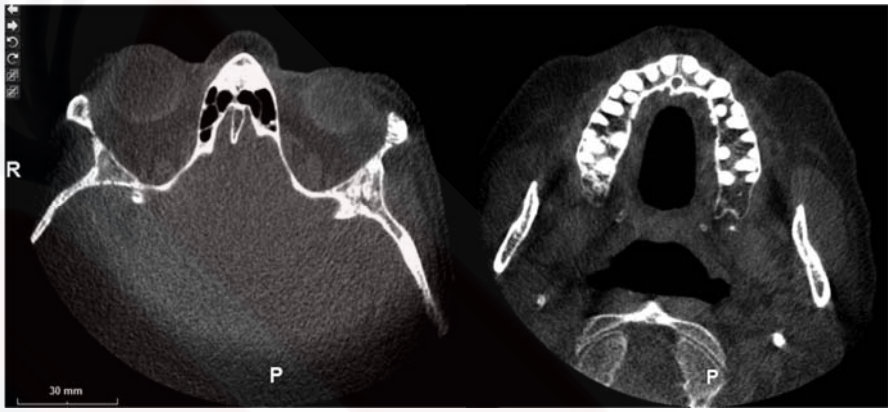
Contrast Used for CT Scans

- In many cases (NOT ALL) the contrast can help in the diagnosis.
- Two types of contrasts: ***IV and oral.***
- The IV contrast is injected into a vein (usually in the arm) and this contrast circulates through the blood stream.
- The oral contrast is swallowed and this contrast highlights the stomach and intestinal track.

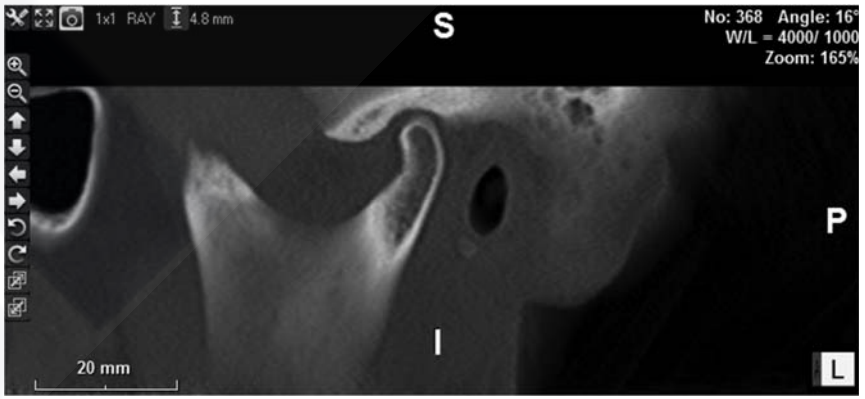
Adjusting the range of CT numbers

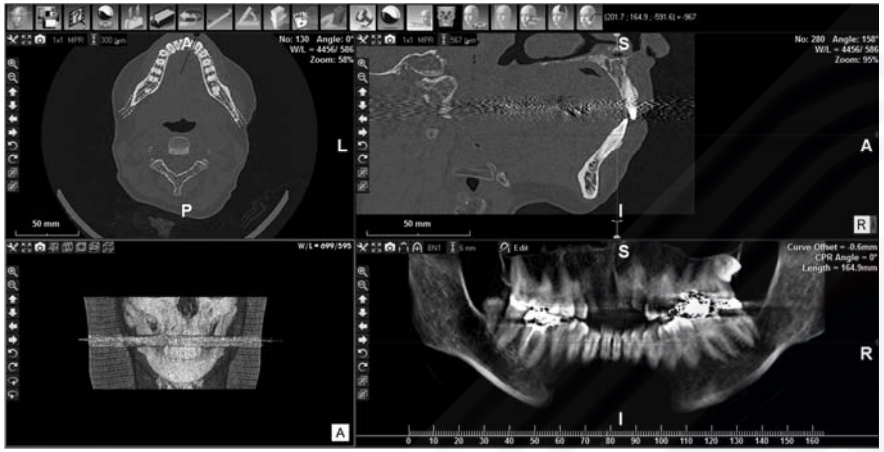
- It is possible to adjust the grayscale visualization of MDCT to enhance the appearance of specific tissues.
- Usually, there are two main types of adjustments the visualization of the CT images:
  - Bone window
  - Soft-tissue window.

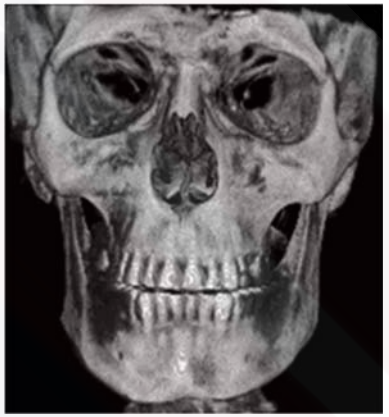

A
P


R
P
30 mm
P

CBCT


1x1 RAY 4.8 mm
S
No: 368 Angle: 16°
W/L = 4000/ 1000
Zoom: 165%
P
I
20 mm
L





Artefacts in CT