Maxillofacial Imaging

Medical Imaging: is the process of creating visual representations of the interior of a body for clinical analysis and medical intervention.

Imaging is an integral part of the head and neck surgeries (trauma, oncology, orthognathic…) from diagnosis through pretreatment assessment to treatment response assessment and subsequent follow up monitoring.

The Maxillofacial imaging modalities are:

1- **Plain Radiograph**
2- **Computed Tomography (CT)**
3- **Cone Beam CT (CBCT)**
4- **Magnetic Resonance Imaging (MRI)**
5- **Ultrasound**
6- **Positron Emission Tomography (PET);**

They are often used in combination in the patient management.

1. Plain Radiographs

a- Panoral Tomography:

Tomograph are radiographs generated from machines that allow the x ray film or sensor and the tube to move around the patients.

The structures in the midline beyond the mandible will split and appear lateral in the OPG as the trachea, cervical vertebrae, hyoid (see the next figure).

For trauma patients;

- a panoral tomogram, or orthopantomogram (OPT) or (OPG) represents the best single overall view of the mandible, including an excellent view of the condyles.
- The combination of a posteroanterior (PA) view of the skull (vertical imaging) and an OPG (horizontal imaging) usually exclude the need for further radiographs in most patients with mandibular fractures.

- The OPG demonstrate the masseter upward displacement of the angle in unfavorable fractures. However, the cervical spine is superimposed on the symphysis in both views and can obscure the detailed assessment of this region.

Two fractures: left parasymphesial –the direct and right angle –the indirect (1: trachea, 2: cervical spine, 3: Hyoid)

For implant the OPG gives sufficient informations about

i. Alveolar height
ii. The position of vital structures as (mental foramen, inferior alveolar canal, nasal and sinus floor).
iii. Follow up assessment as evaluation of bone loss around the implant.

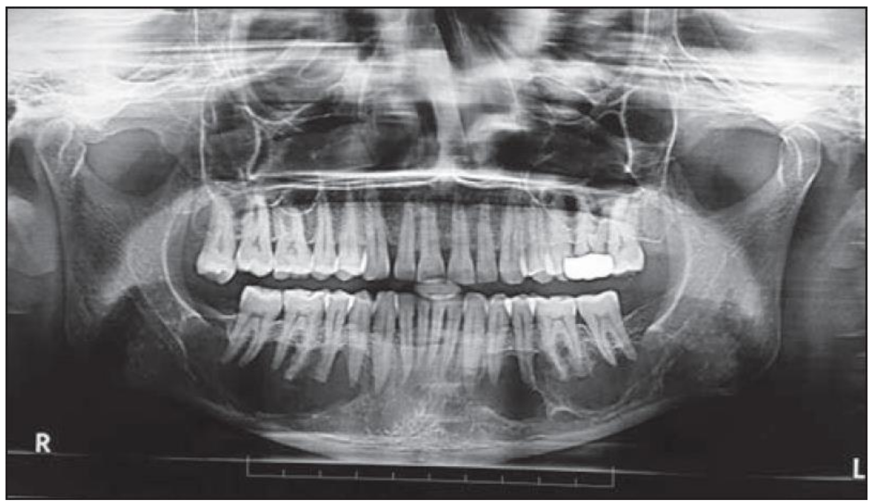
For Assessment of pathological lesions: the OPG is the best modality for assessment of various lesions of the mandible (tumors, cysts, osteomyelitis,…..etc) with demonstration of

a) Size and extension of the lesion
b) The nature of the lesion (osteolytic or osteosclerosing),
c) The relation with adjacent teeth (displacement – usually cyst /or roots resorption – usually tumors/ or non displacement- usually Keratocyst).
d) The nature of the margins (well localized – slow growing or diffused non localized –fast growing)
   The last 2 give a clue to the degree of lesion aggressiveness and speed of progression.

Radiopaque odontoma at the left body of the mandible

Gorlin Koltz (multiple keratocysts)

- **Non displaced roots with well defined margins of the lesions**



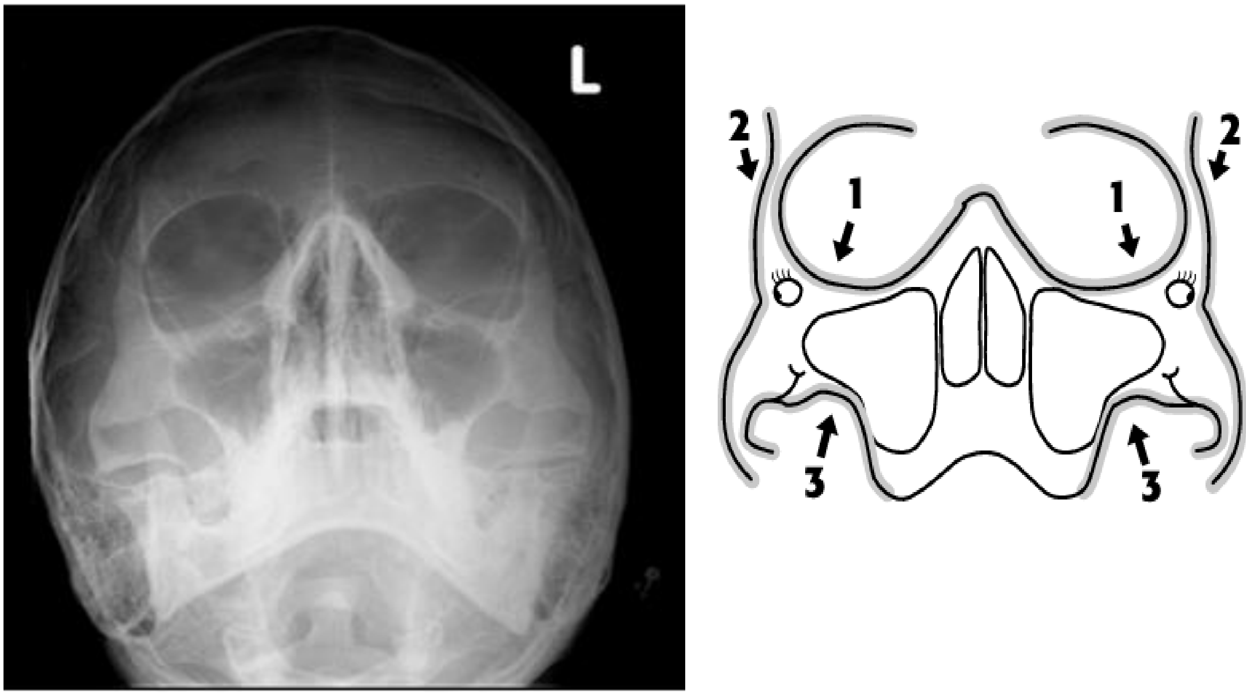
b- Postero- Anterior (PA) view:

- The standard PA view of the skull (vertical view imaging) demonstrates fractures of the body and angle together with the degree of displacement in the sagittal plane (medial pterygoid muscle displacement)
- Combining it with an OPG provides the best overall assessment of mandibular fractures using plain radiographs alone.
- The condylar head may be obscured by superimposition of the skull base and mastoid process. For this reason; modification in the cone angulation may be necessary as in Townes projection and reverse Townes projection which demonstrate the condylar region very well.

PA skull showing left angle fracture with displacement by medial pterygoid muscle (right) and same fracture without displacement (left)

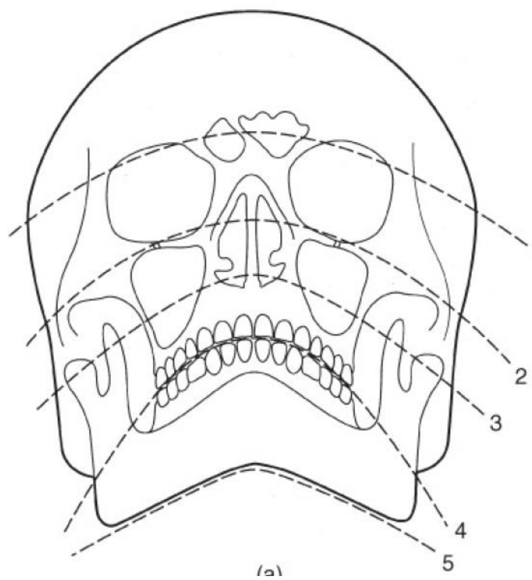
c- Occipito- Mental (OM) view

- It is the single most useful plain radiograph in midfacial trauma.
- The patient stand in upright position with nose and chin touching the film, the tube angled above the horizon with different angulations according to the needed request (orbital floor, sinuses view or for midface fractures). The common angulations are 10 ^{o}, 20 ^{o}, and 30 ^{o} above the horizon.
- Ideal for zygomatic fractures but Lefort fractures is better to be visualized by CT scan.
- The zygomatic bone can be visualized clearly in this view and resemble an elephant head.
- These views need to be examined systematically along four curved search lines, referred to as Campbell's lines, A fifth line that follows the lower border of the mandible was suggested later by Trapnell. (as in the diagram below).



OM view (on the left), diagram representing the elephant head (on the right)

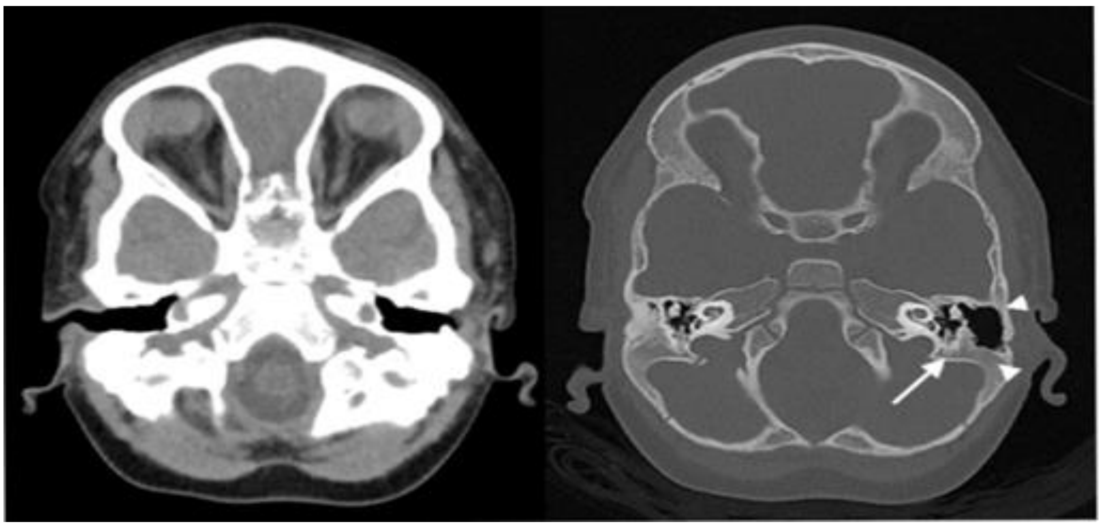
The Four Campell's lines and the fifth Trapnell line



2. Computed Tomography (CT) Scan

- CT depends on multiple x-ray projections through part of the body. The patient is exposed to radiation as the x-ray source to rotate around the patient.
- The patient is exposed to high radiation dose as the x-ray source rotate while the patient moves inside the machine and that's why the scan will be in spiral or helical design.
- In CT high resolution images can be reconstructed in any plane (axial, Coronal, Sagittal and 3D).

- Interpretation views include: **bone window** (the cancellous bone can be visualized with faint soft tissues) and **soft tissue window** (the bones appear bright and blurred).
- CT scans demonstrate excellent bone anatomy, pathology and good soft tissue contrast but not as good as MRI.
- A common problem with CT is artifact arising from high-density material in the area of interest. This is a problem in the oral cavity, where high-density fillings may degrade large areas of the image.
- CT scanning for the malignancies is routinely performed with intravenous contrast (iodine based) for outlining the tumor mass.



Axial view of skull base in soft tissue window (left) and bone window (right)

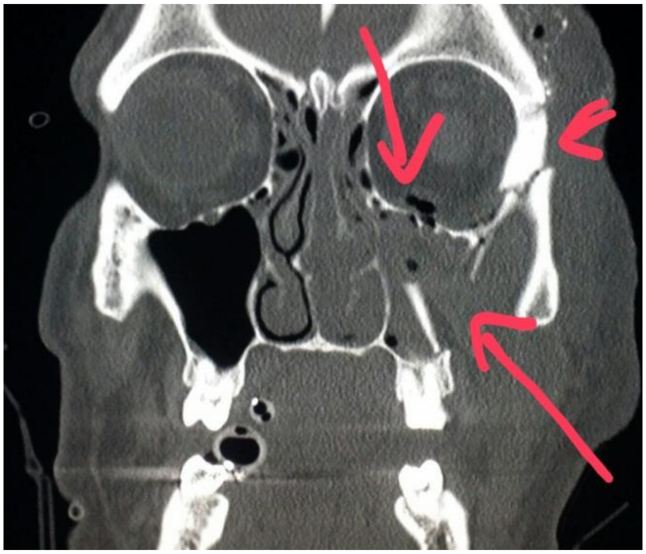
- **Most common indications of CT in maxillofacial Surgery:**

✓ Extensive fractures of the midface (including naso-orbito-ethmoid NOE, comminuted zygomatic complex fractures and isolated orbital trauma).

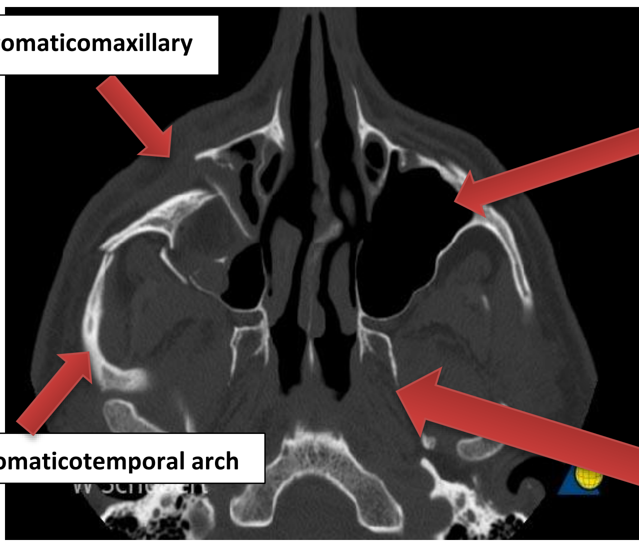
✓ Comminuted fractures of the mandible and complex injuries to TMJ.

✓ Assessment of tumors extension in the region and ct neck for assessment of lymph nodes involvement in case of malignancy.

✓ Construction of a three-dimensional model may be helpful to facilitate pre-surgical planning and the pre bending of a rigid reconstruction plate.



Case 1: Coronal view of CT showing left ZMC fractures in bone window.



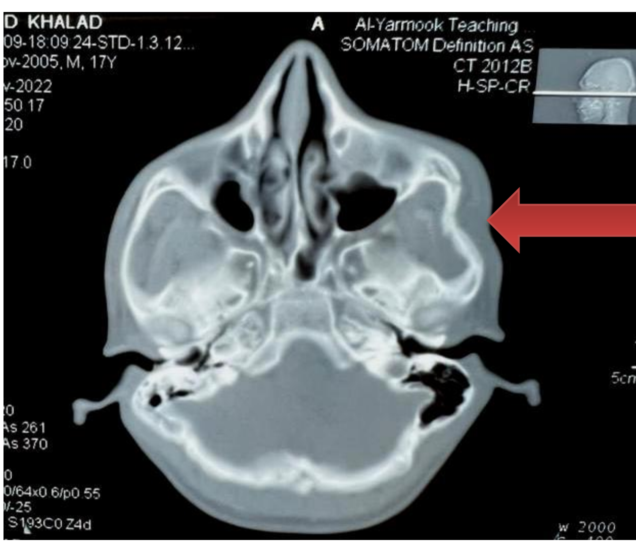
Zygomaticomaxillary

Left Maxillary sinus

Zygomaticotemporal arch

Pterygoid plates (v shape posterior to maxilla)

Case 2: Axial view of CT showing right ZMC fractures in bone window



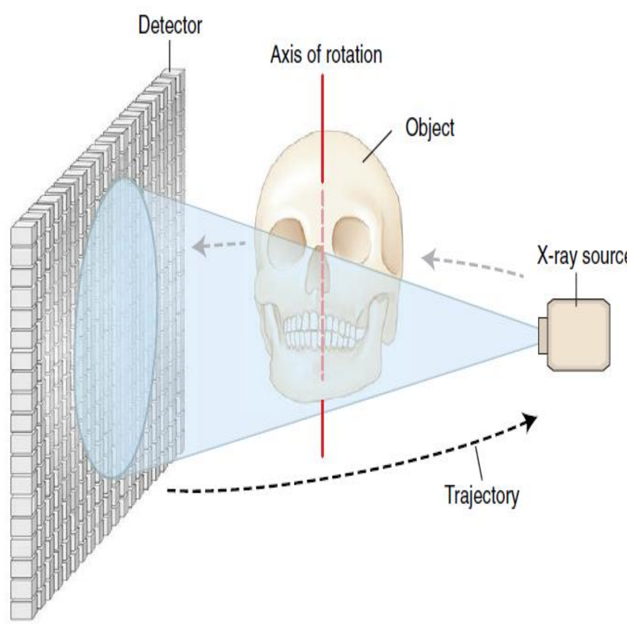
Scanogram

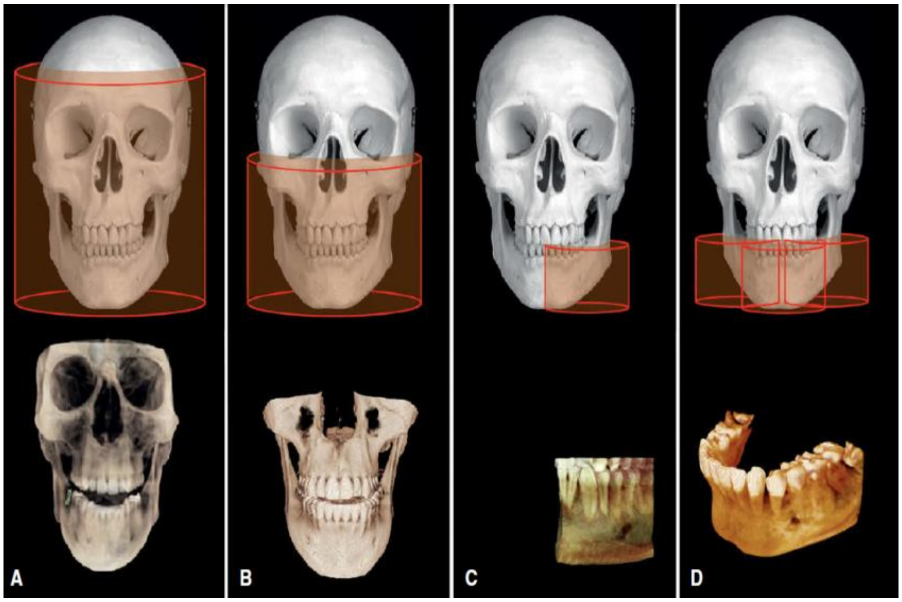
Case 3: Axial view of CT showing left zygomatic arch fracture in bone window

Case 4: 3D view for multiple facial fractures

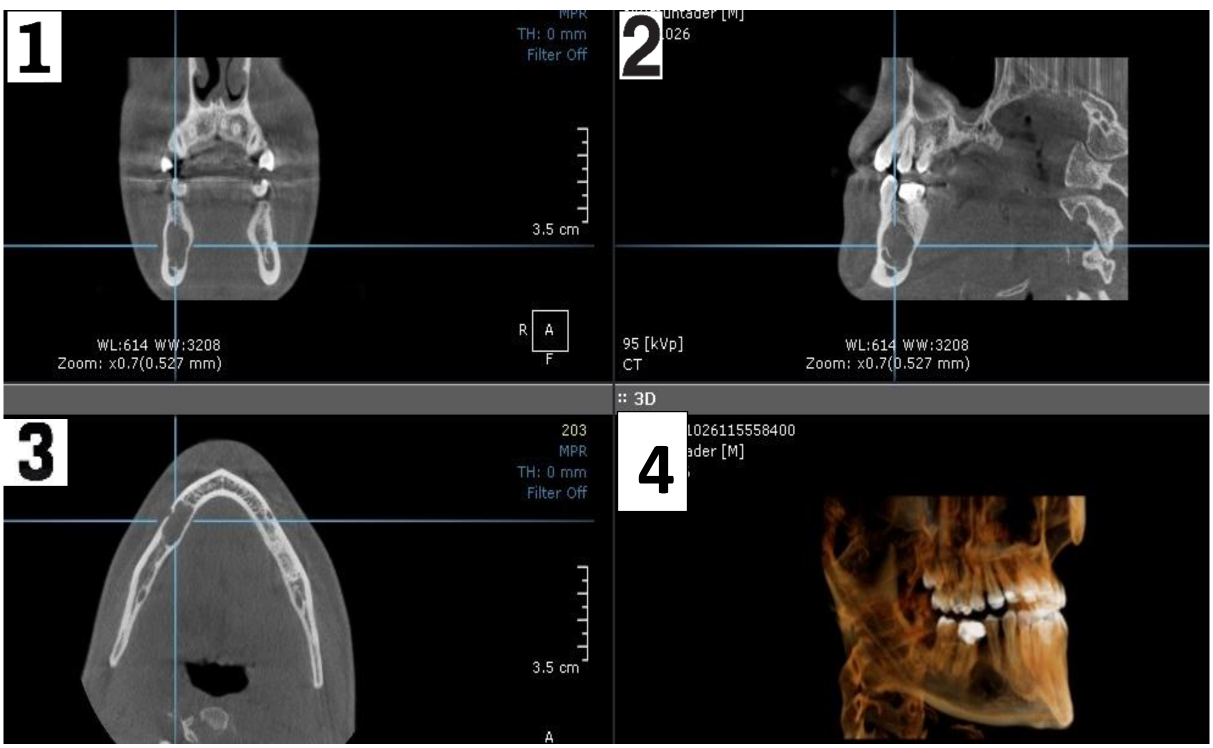
3. Cone Beam CT (CBCT)

- It uses a cone-shaped or pyramid shaped ionizing radiation that is directed through the region of interest in the planes (axial, sagittal, and coronal) and 3D images.
- CBCT is much less radiation that conventional CT and can be guided to whole facial region, to both jaws, or single jaw only.
- CBCT is designed for the imaging of maxillofacial region only.
- CBCT is inferior to CT but far more better than OPG in assessment because it provides views in different sections same as CT (axial, coronal, sagittal, and 3D) that gives a better visualization of the area.
- It is more preferable than OPG for assessment of cases of dental implant and impacted teeth.





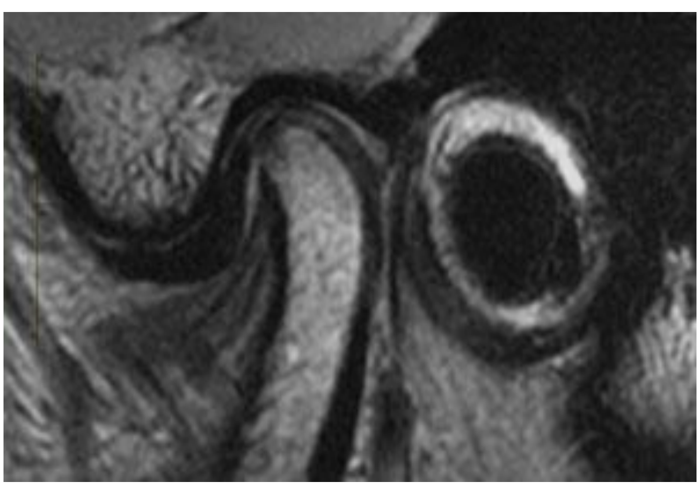
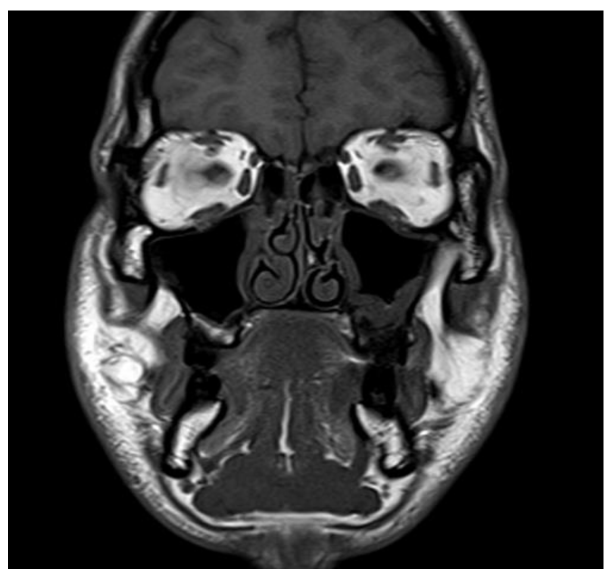
Different sections of CBCT according to the type of machine



Different Sections of CBCT for mandibular cyst in Coronal (1), sagittal (2), Axial (3), and 3D (4)

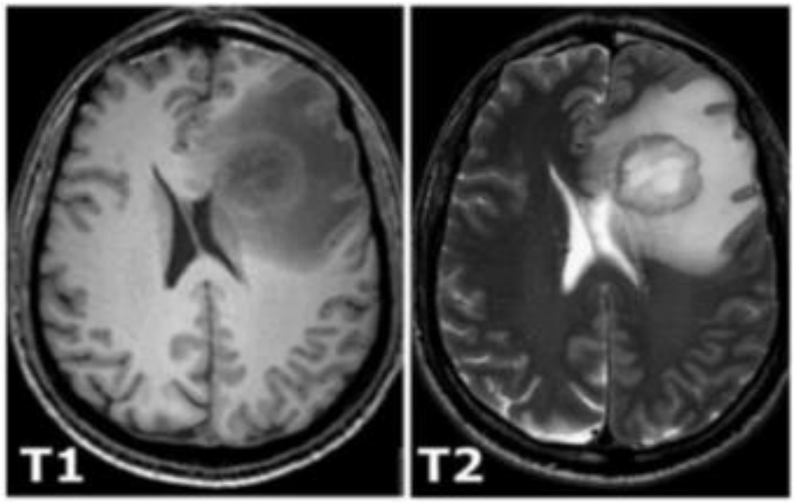
4. Magnetic Resonance Imaging (MRI) Scan

- MRI does not involve X-rays or the use of ionizing radiation as CT. The patient lies within a high strength magnetic field, usually (1.5 – 3 Tesla) for head and neck images.
- The principle is that the machine produces radio waves that transmitted through the patient, these waves provoke the tissues to emit wave signal that detected by scanners. The strength of signals depends on proton (hydrogen ion) intensity. Since the hydrogen is present in the water and the water is mainly available in body soft tissues but low percentage in the bones, that's why the MRI cannot demonstrate the bones.
- In **facial trauma** it is rarely indicated but it is the only imaging method for visualizing the meniscus of the TMJ, therefore it used in suspected meniscal damage.
- Interpretation includes: T1 weighted images (dark CSF), T2 weighted images (bright CSF) and fat suppression images. Always remember the second world war WWII as a differentiation between T1 and T2 because the water (CSF) appear white in T2 so the abbreviation for Water White in T2 is (WWII).
- The I.V. contrast medium in MRI is gadolinium which gives enhancement in T1 and T2 weighted images.
- **In oncology**: It is very precise in soft tissue imaging and that's why it is preferable to CT in assessment of tumor extension in soft tissue and lymph nodes metastasis.

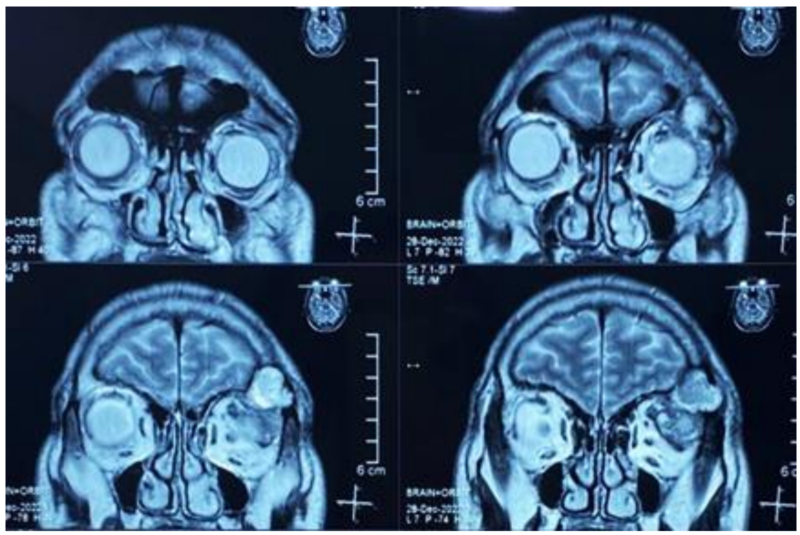



On the right:MRI showing TMJ meniscus (T1), On the left: Coronal view (T1)

Brain lesion in T1 and T2



MRI of orbital mass in left orbit (T2)



Limitations and contraindications:

- Machine design (closed MRI) is not suitable for patients with cluster phobia (recently solved by the open MRI).
- Acoustic noise which is the audible noise produced by the scanner and ear protection must be worn.
- Metal objects that are attracted by magnetic field should be removed before imaging.
- There is inference with the action of cardiac pacemaker and other electronic devices.
- The imaging is expensive and takes more time compared to CT.

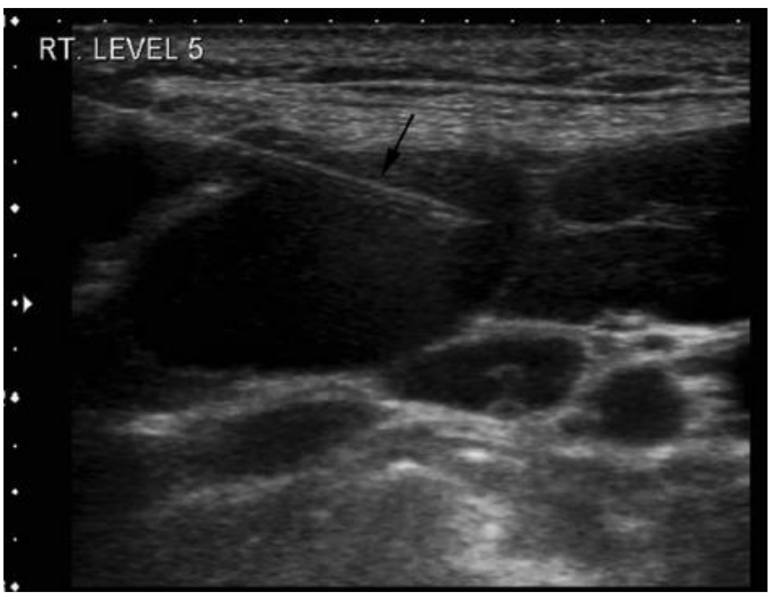
5. Ultra Sound (U/S)

- Ultrasound images are the amplitude of reflected high-frequency sound waves.
- Lower-frequency ultrasound penetrates further than higher frequencies therefore frequencies of 2.5 to 5 MHz are used in the abdomen (deep structures) while higher frequency as 12 MHz is used for the head and neck lesions (superficial), the less penetration; the better the resolution.
- The lighter objects in ultra sound are termed hypoechoic while the darker objects termed as echogenic.
- **Doppler ultra sound** is modification in the device that was made to detect the blood flow of the examined object, and also determine the speed of the flow by color code so that the examiner can recognize the feeder vessel as artery (high flow speed or vein low flow speed).

  The main use of Doppler ultra sound is to study the vascular anatomy of the examined object.

Indications

- ❖ Assessment of salivary gland pathology (tumor, stones …)
- ❖ Assessment of vascular anomalies and the flow rate (Doppler study)
- ❖ Assessment of neck lymph nodes in malignant tumors of the head
- ❖ Adjunct to other procedures as u/s guided FNA biopsy (fine needle aspiration)



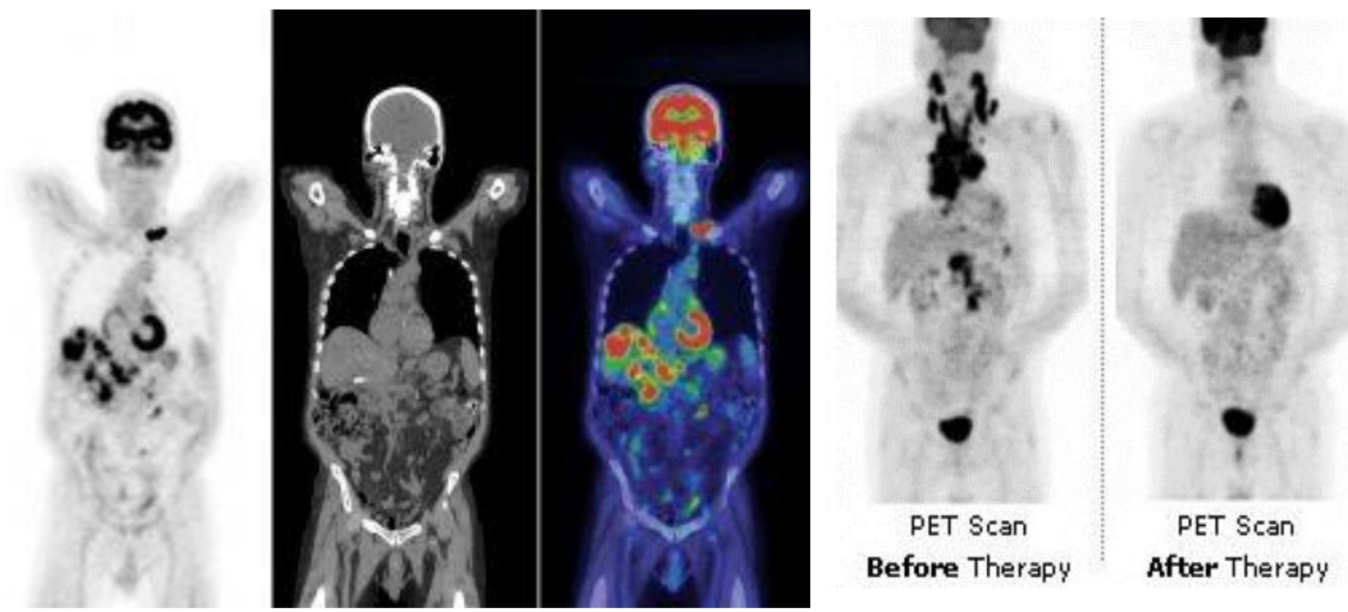
Ultrasound (gray-scale) image of cutting needle biopsy *(arrow)* of an abnormal lymph node.

6. Positron Emission Tomography (PET) Scan

- PET/CT is a functional imaging technique that identifies pathology by detecting abnormal tissue metabolism.
- It relies on radio-tracers that are radioactive substances that given intravenously to the patient, and taken up by cells. Malignant cells trap more radiotracer compared with non-malignant cells.
- The radiotracer is 18F-fluoro-2-deoxy-D-glucose (18F-FDG), which reflects glucose metabolism.
- The images formed by the PET scan are blurred and that's why it is combined with CT to get accurate images and known as PET CT.

PET/CT is mainly used for malignancies

- Detection of occult primary
- Staging of the tumor
- Assessment of treatment response



The two images on the right show PET scan for assessment of treatment response
The three images on the left show the difference between PET scan, CT scan and PET CT

This is the end of the Lecture, Good Luck