ADVANCED IMAGING MODALITIES

The advanced imaging modalities include equipment and principles that **are beyond the routine needs of most general dental practitioners**, they include:

1. COMPUTED TOMOGRAPHY

Computed tomography (CT) is a well-accepted technique for entire body evaluation.

CT scanners use X-rays to produce **sectional or slice** images. Here the radiographic

film is replaced by very sensitive **crystal** or **gas detectors**.

The detectors measure the intensity of the X-ray beam emerging from the patient and convert this into digital data which are stored and can be manipulated by computer.

Equipment and theory

The CT Scanner is essentially a large equipment (the **gantry**) with a large circular hole. The patient lies down with the part of the body to be examined within this circular hole. The gantry houses the **X-ray tube head** (emerge fan shaped beam) and the **detectors**. CT has undergone several evolutions and nowadays multi- detectors CT scanners (MDCT) have been evolved which have better application in clinical field

*__N.B__. CT scan machine doesn't contain image receptor cassette (or film) just like that used with extra oral radiographic techniques.

Main indications for CT in the head and neck:

MDCT has several applications in the diagnosis and treatment of dentomaxillary disease such as:

• Infections, including osteomyelitis and space infections

• Midfacial and mandibular trauma

• Investigation of the TMJ.

• Developmental anomalies of the craniofacial skeleton

• intraosseous cysts and neoplasms of the jaws with tumor staging

Advantages of CT:

It provides **axial (horizontal)**, **coronal** and **sagittal** views of the tissue.

• It shows anatomically precise location of the lesion and its extent.

• Because the image that is produced is formulated by the computer, areas of interest may be selectively viewed and enlarged by using computer programmers.

• As the information is stored in the computer it can be viewed any time in the absence of patient.

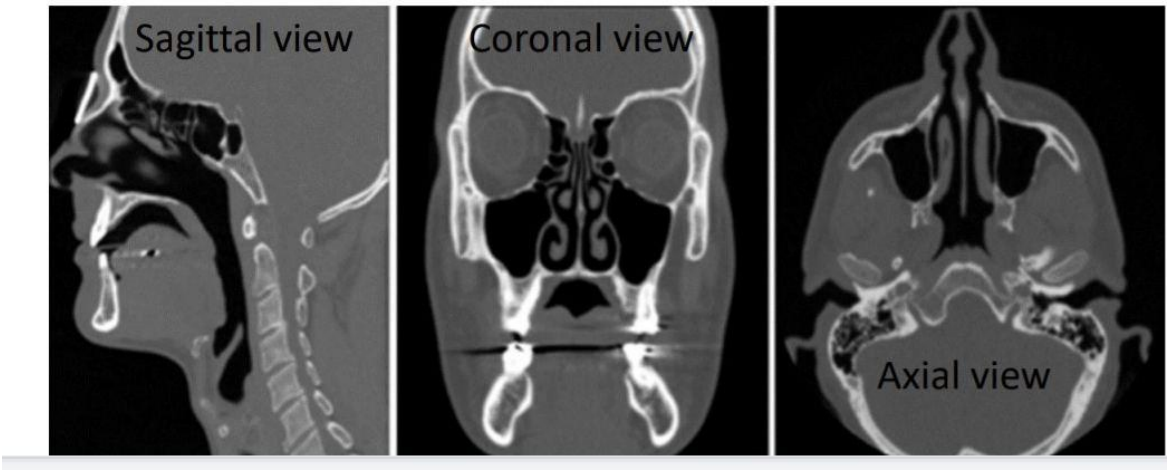
• Image can be manipulated. •

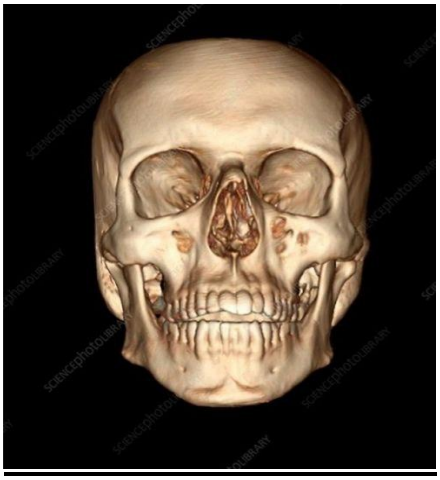
Disadvantages of CT

•Is sophisticated, costly and expensive

• Very high-density materials such as metal bullets and dental restorations produce severe artifacts on CT scan, which makes the interpretation difficult.

• There is an inherent risk associated with the contrast medium.





2. CONE BEAM COMPUTED TOMOGRAPHY (CBCT)

Dental cone beam computed tomography (CT) is a special type of x-ray machine used in situations where routine dental or facial x-rays are not sufficient. It is **not used routinely because the radiation exposure from this scanner is significantly more than regular routine dental x-rays**. This type of CT scanner uses a special type of technology to generate three dimensional (3D) images of dental structures, soft tissues, nerve paths and bone in the craniofacial region in a single scan. Images obtained

with cone beam CT allow for more precise treatment planning. It provides a multiplaner view in coronal, sagittal and axial plane in one rotation only in addition to 3D view.

CBCT is composed of **X-ray source** within a* **rotating gantry**. A* **divergent pyramidal** or **cone-shaped source** of ionizing radiation is directed through the middle of the region of interest . CBCT scanner utilizes **a* 2D X-ray detector** on the opposite side, which allows for a single rotation of the gantry to generate a series of 2Dscan image. ***Computer** is used to display the images

Dental cone beam CT was developed as a means of producing similar types of images as conventional CT, but with **simpler technique** by using **much smaller and less expensive machine and** that could be placed in an outpatient office.

Advantages:.

**Rapid scan time (5-40 second)

**Beam limitation (you can select the field of view FOV so reduce patient exposure)

**Image accuracy

**Reduced patient radiation dose (in compare to CT)

**Image manipulation

Disadvantages:

**Extinction artifacts

**Beam hardening artifacts

**Ring artifacts

**Motion artifacts (misalignment artifacts)

Application of CBCT

**Implant imaging

**orthodontic and orthognathic surgeries

**endodontics **Periodontics

**TMJ diagnosis

** Assessment of maxillary sinus, nerve canals and nasal cavity

**Impacted teeth (Third molar and canine) **Evaluation of facial trauma

3. Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging (MRI) is an imaging technique with a revolutionary impact in diagnostic imaging. it **uses nonionizing radiation**. Instead, it depends on the **magnetic field** and **radio** frequency waves (RF)

MRI principle and technique:

The essential principle of MRI involves the behavior of protons (positively charged nuclear particles) in the simplest atom which is **hydrogen** that consisting of one proton in the nucleus so it used to create the MRI image.

The magnetic field in MRI scanner is provided by external powerful permanent magnet with strength range from (0.1 to 7 Tesla), 1.5 Tesla is the most commonly used (which is about 30,000 times the strength of the earth's magnetic field). The strength of the MRI signal depends on the degree to which hydrogen is bound within a molecule. **Tightly** bound hydrogen atoms (in **bone**) produce **weak** signal. While **loosely** bound or mobile hydrogen atoms (in soft tissues and liquids) produce **strong** signal. It makes images with **excellent soft-tissue resolution.**

The MRI images either **T1-weighted** images are more commonly used to demonstrate **anatomy** or **T2 weighting** are used to depict **pathologic changes**, such as inflammation and neoplasia. In MRI the most common Contrast agents used is **Gadolinium** that is making the tissues appear brighter.

Advantages of MRI

1. It offers best resolution of soft tissues

2. No ionizing radiation is involved

3. provides multi planar imaging, image manipulation can be done.

Disadvantages of MRI

1. Relatively long imaging times

2. Patients with claustrophobia may not be able to tolerate the narrow space within the MRI scanner this can be managed by using open MRI, chemical sedation, general anesthesia, or listening to music on headphones.

3. Hazard associated with the presence of ferromagnetic(metal)substances in the patient's body, the strong magnetic fields can move these objects, cause excessive heating, or induce strong electrical currents, which may harm the patient, so MRI is contraindicated in patients with cardiac pacemakers, some cerebral aneurysm clips, vagus nerve stimulators, insulin pumps, cochlear implants, and in patients with embedded ferrous foreign bodies, such as shrapnel or bullets.

4. Metals dental restorations do not move but distort the image, Removable dental appliances must be removed prior to MRI scanning.

5. There is medical evidence that a tattoo can cause a reaction (burning sensation) during MR imaging because some tattoo inks containing iron oxide

6. Contraindicated In first trimester of pregnancy (especially with using Gadolinium contrast agent)

7. equipment is very expensive

Applications of MRI in Maxillofacial Diagnosis

Because of its excellent soft-tissue contrast resolution, MR imaging is useful in evaluating soft tissue conditions (Bone does not give an MR signal, a signal is only obtainable from bone marrow).

Applications of MRI in dentistry include:

1. Evaluation of TMJ
2. Evaluation of neoplasms
3. Evaluation of salivary gland diseases
4. Evaluation of vascular lesions in the orofacial region
5. Evaluation of early jaws osteomyelitis
6. Evaluation of maxillary sinus, nasal cavities, the tongue, and floor of mouth
7. Functional MRI (fMRI) which is identification of motor and sensory areas of the brain in relation to pain, occlusion, fear, love, smell,…
8. Assessment of intracranial lesions

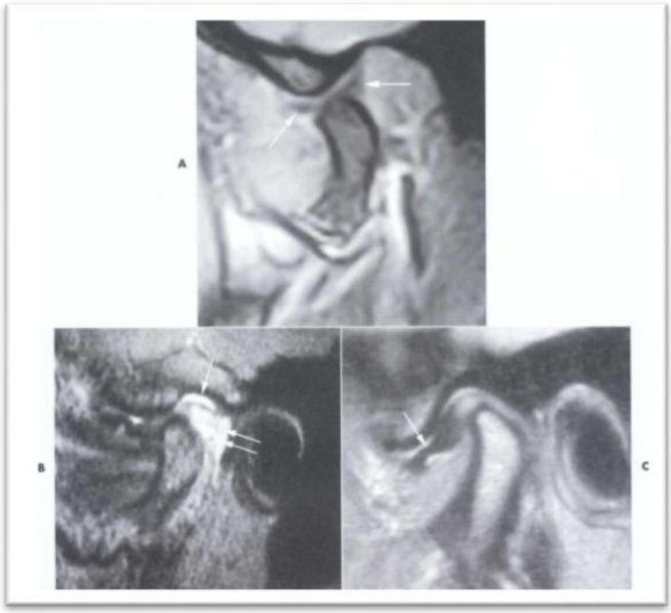
ملاحظات مهمة جدا

***all MRI & CT & CBCT produces sectional or slice or multiplanner image in axial, sagittal & coronal plane in addition to 3D image**

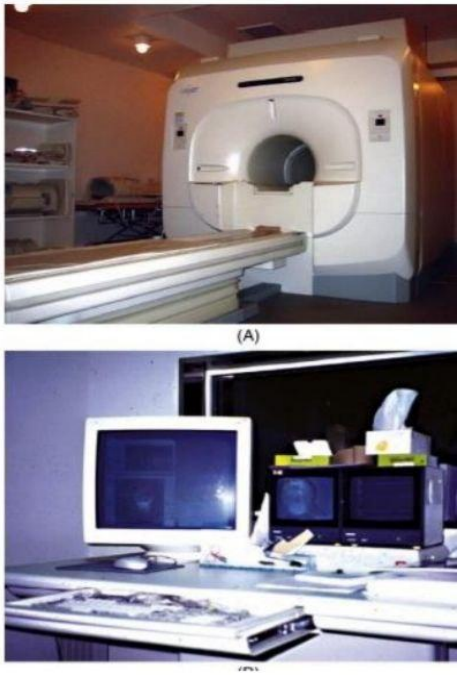
*** MRI uses non ionizing radiation while both CT & CBCT use x ray (ionizing radiation) with the amount of radiation in CT scan is higher than that in CBCT.**

*** Despite that the amount of radiation in CBCT is lower than CT; but it is higher than that in routine dental radiographic techniques such as periapical, bitewing & occlusal so that this technique (CBCT) is not indicated for routine checkup in which we can obtain a significant information with the routine dental techniques.**

	CT	MRI
1	uses X-rays (ionizing radiation) it a good tool for examining hard tissue such as bone	uses non-ionizing radio frequency (RF) signals is best suited for soft tissue
2	contrast in CT images is generated from X-ray attenuation	variety of properties may be used to generate contrast in MR images.
3	Contrast agents is iodine or barium	Contrast agents is gadolinium
4	limited to axial plane images from which images reconstructed in any plane	generate cross-sectional images in any plane
5	best for solid tumors of the abdomen and chest	Best For brain tumor detection
6	more widely available, faster, and less expensive	Long time, expensive



MRI image of TMJ



MRI device

4. Ultrasonography (US)

Is an advanced modality in oral and maxillofacial imaging, this technique based on sound waves without the use of ionizing radiation.

US principle and technique: The US unit consists of a **transducer** and the **monitor** on which sonogram can be seen. A transducer is a device that can convert electrical energy into sonic energy with frequencies range (1 to 20 MHz). The transducer emitting ultrasound is held on the body part being examined. The ultrasonic beam passes through tissues of different acoustic impedance. some Sonic waves are reflected and the rest are absorbed .

The reflected waves (echo) returned to the transducer where it is detected, amplified, processed, and displayed on monitor as a digital image.

Interpretation of sonograms relies on the tissues signals. Tissues that do not produce signals, such as fluid-filled cysts, are said to be **anechoic** and appear **black**. Tissues that produce a weak signal are **hypoechoic**, whereas tissues that produce intense signals, such as ligaments, skin, or needles or catheters, are **hyperechoic** and appear **bright**

Applications of ultrasonography in oral and maxillofacial imaging

1- Evaluation of benign and malignant neoplasms in head and neck region (the thyroid, parathyroid, lymph nodes, sinuses)

2- Salivary glands pathologies (neoplasm, stones, inflammation, and Sjögren's syndrome)

3- Evaluation of vessels of the neck, including the carotid artery for atherosclerotic plaques

4- Ultrasonography is also used to guide fine-needle aspiration.

5- More recent advances include 3D imaging of a fetal face

6- Color Doppler ultrasonography for evaluation of blood flow

7- Detection of Orofacial Fracture

8- Detection of facial muscles thickness