L.18 Advanced Imaging

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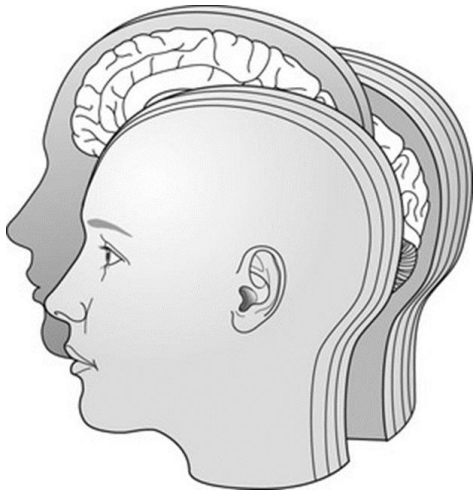
Tomography:

Tomography is a specialized technique for producing radiographs showing only a section or slice of a patient tomographic image (or slice) shows the tissues within that section sharply defined and in focus. The section is thus referred to as the focal plane or focal trough. Structures outside the section are blurred and out of focus.

By taking multiple slices, three-dimensional information about the whole patient can be obtained. Production of each conventional tomographic slice requires controlled, accurate movement of both the X-ray tube head and the film during the exposure.



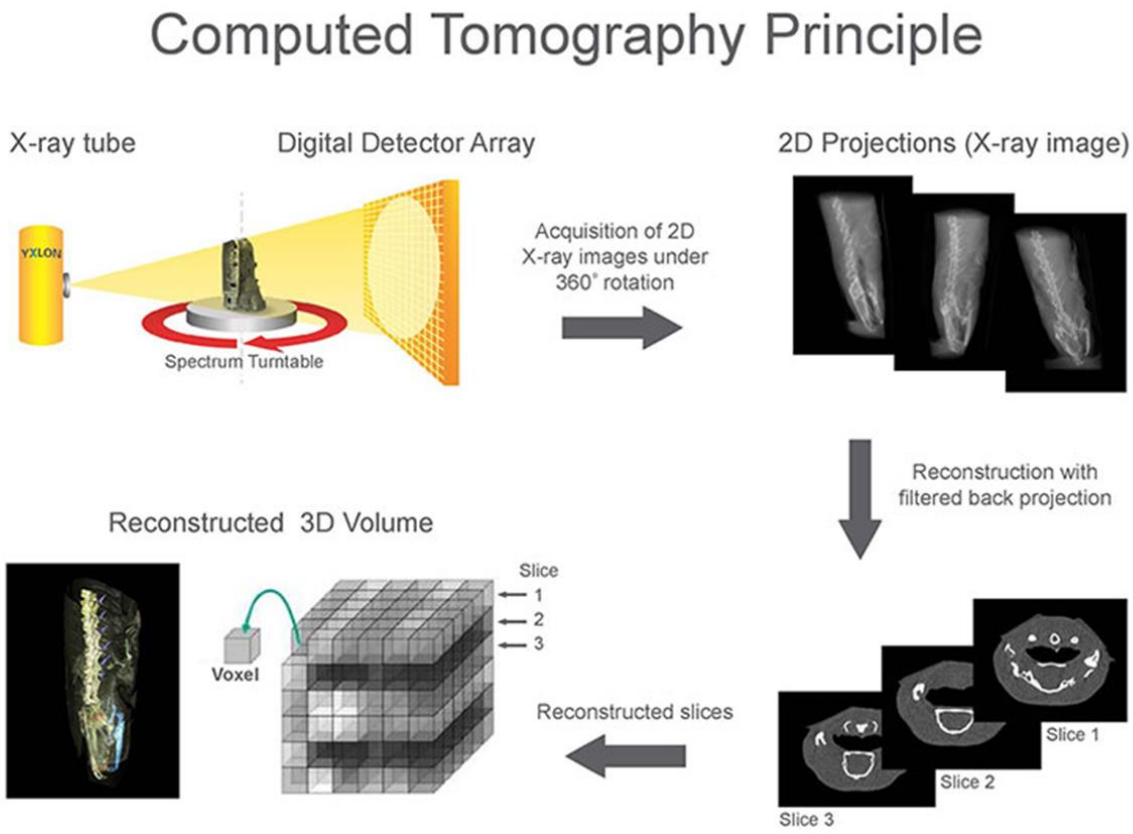
Computed tomography (CT):

CT scanners use X-rays to produce sectional or slice images, in its simplest form a CT scanner consists of a radiographic tube that emits a finely collimated, fan-shaped x-ray beam that is directed to a series of scintillation detectors or ionization chambers (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 a computer.

This numerical information is converted into a grey scale representing different tissue densities, thus allowing a visual image to be generated.

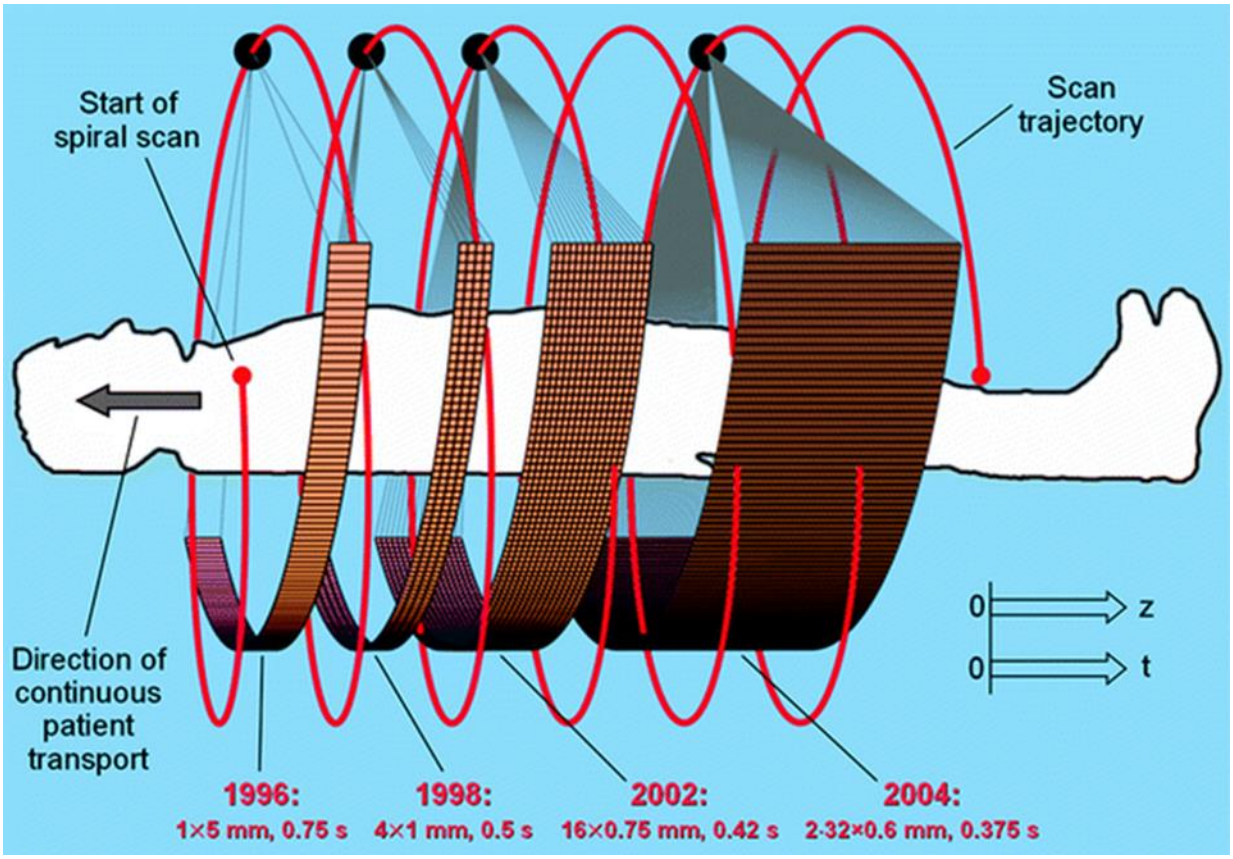
The image consists of a matrix of individual pixels representing the face of a volume called a voxel.



How does CT work?

During a CT scan, the patient lies on a bed that slowly moves through the gantry while the x-ray tube rotates around the patient, shooting narrow beams of x-rays through the body.

Instead of film, CT scanners use special digital x-ray detectors, which are located directly opposite the x-ray source.



Main indications for CT in the head and neck:

1. Investigation of intracranial diseases including tumors, hemorrhage and infarcts.

1- Investigation of suspected intracranial and spinal cord damage following trauma to the head and neck.

2- Assessment of fractures involving:
   a. The orbits and naso-ethmoidal complex.
   b. The cranial base.
   c. The cervical spine.

3- Tumor staging; assessment of the site, size and extent of tumors, both benign and malignant, affecting:
   a. The maxillary antra.
   b. The base of the skull.
   c. The pterygoid region.
   d. The pharynx.
   e. The larynx.

4- Investigation of tumors and tumor-like discrete swellings both intrinsic and extrinsic to the salivary glands.

5- Investigation of osteomyelitis.

6- Investigation of the TMJ.

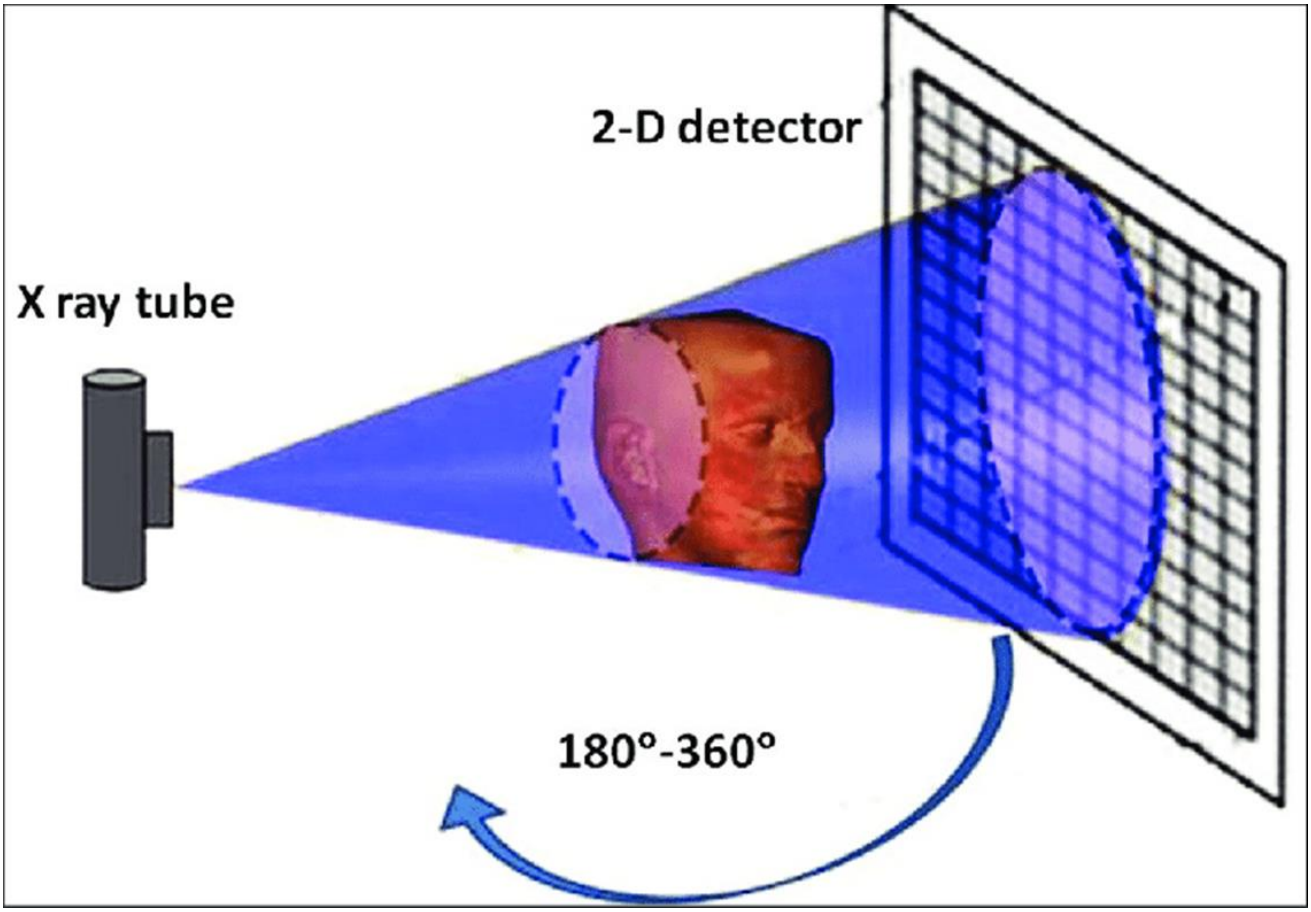
7- Preoperative assessment of maxillary and mandibular alveolar bone height and thickness before inserting implants.

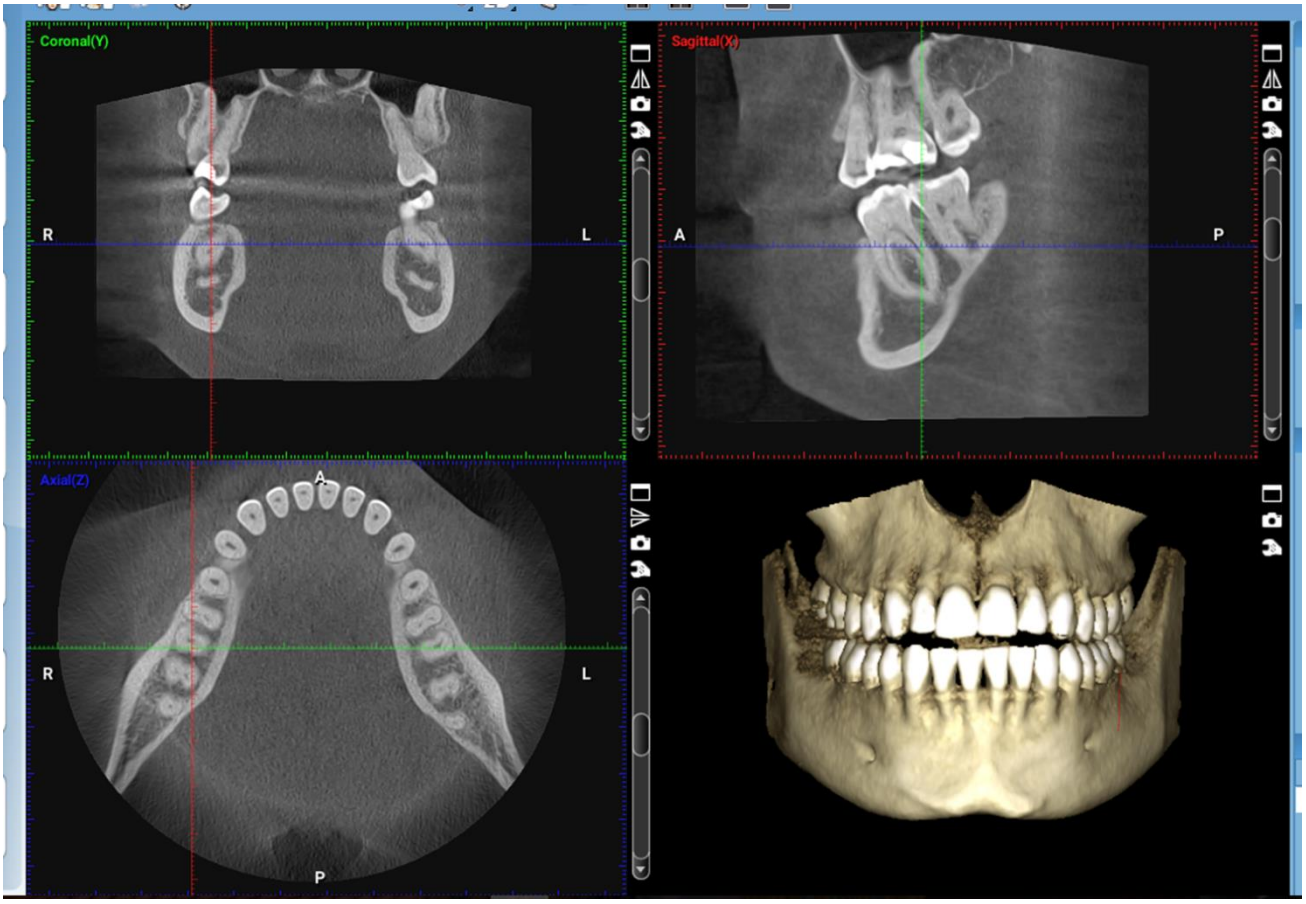
Disadvantages:

1- The equipment is very expensive.
2- Metallic objects, such as fillings may produce marked streak or star artifacts across the CT image.
3- Inherent risks associated with IV contrast agents.

Cone-beam CT (CBCT):

CBCT is a recent technology. A divergent pyramidal- or cone-shaped source of ionizing radiation is directed through the middle of the area of interest onto an area x-ray detector on the opposite side. These recordings constitute "raw data" that is reconstructed by a computer algorithm to generate cross-sectional images.





Advantages of cone-beam CT in dentistry:

1- Rapid scan time: may range from approximately 1 minute to 20 minutes.
2- Beam limitation: Collimation of the CBCT primary x-ray beam enables limitation of the x-radiation to the area of interest.
3- Reduced patient radiation dose; Comparison with patient dose reported for maxillofacial imaging by conventional CT (approximately 2000 mSv) indicates that CBCT (50.3 microsievert) provides substantial dose reductions of 98.5%.
4- Multiplanar reformation.

Limitations of cone-beam CT imaging:

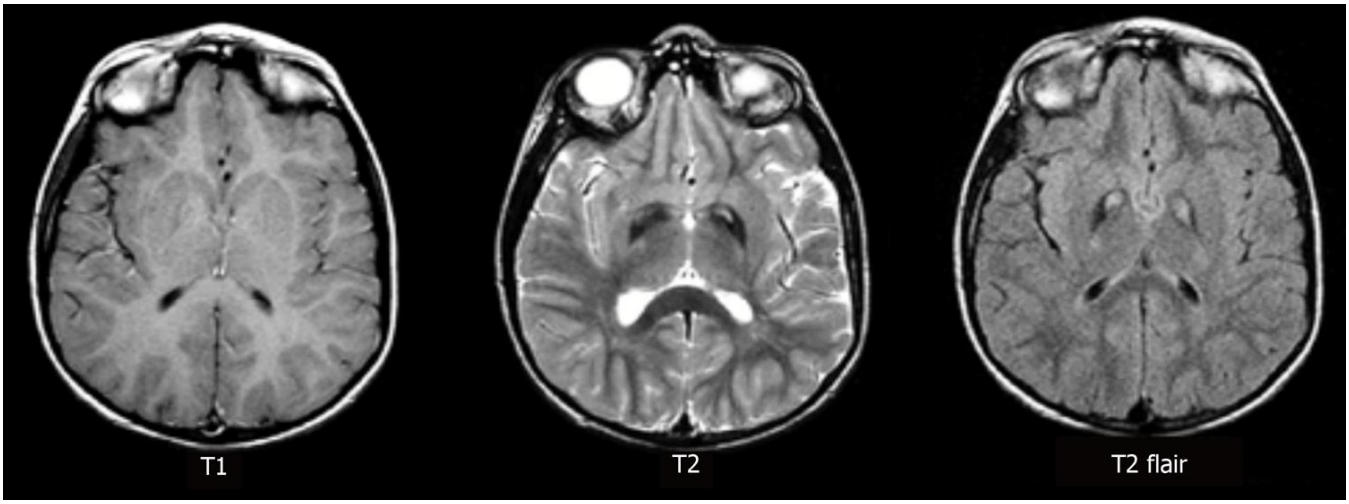
1- Poor soft tissue contrast: scattered radiation contributes to increased image noise.
2- X-ray beam artifacts: Because the CBCT x-ray beam has lower mean kilovolt (peak) energy.
3- Patient-related artifacts: Patient motion can cause misregistration of data, which appears as unsharpness in the reconstructed image.

Clinical applications:

1- Investigation of jaw pathology including cysts, tumors and fibro-osseous lesions.
2- Investigation of the paranasal sinuses.
3- Investigation of the bony components of the TMJ.
4- Pre- and post-implant assessment.
5- Orthodontic assessment, both dental development and skeletal base relationship.
6- Assessment of wisdom teeth, in particular their relationship to the inferior dental canal.
7- Evaluation of facial trauma.

Magnetic resonance imaging (MRI):

MRI is an important technique that is essential for diagnoses in the maxillofacial area. It is a scanning method that obtains tomographic images of the human body using a magnetic field. In contrast to computed tomography, it does not utilize X-rays and, therefore, represents a noninvasive test that lacks radiation exposure. It is particularly effective for soft-tissue diagnoses. MRI involves imaging protons in vivo. Protons emit a signal when a radio frequency pulse is applied in a magnetic field; the MRI device then forms an image from these signals. The basic images produced are T1- and T2-weighted images; comparison of these images is the first step of MRI-based diagnosis.



Main indications for MRI in the head and neck:

1- Assessment of intracranial lesions.
2- Tumor staging (salivary glands, tongue and floor of mouth).
3- Investigation of the TMJ.

Advantages:

1- Ionizing radiation is not used.
2- No adverse effects have yet been demonstrated.
3- Image manipulation available.
4- High-resolution images can be reconstructed in all planes (using 3D volume techniques).

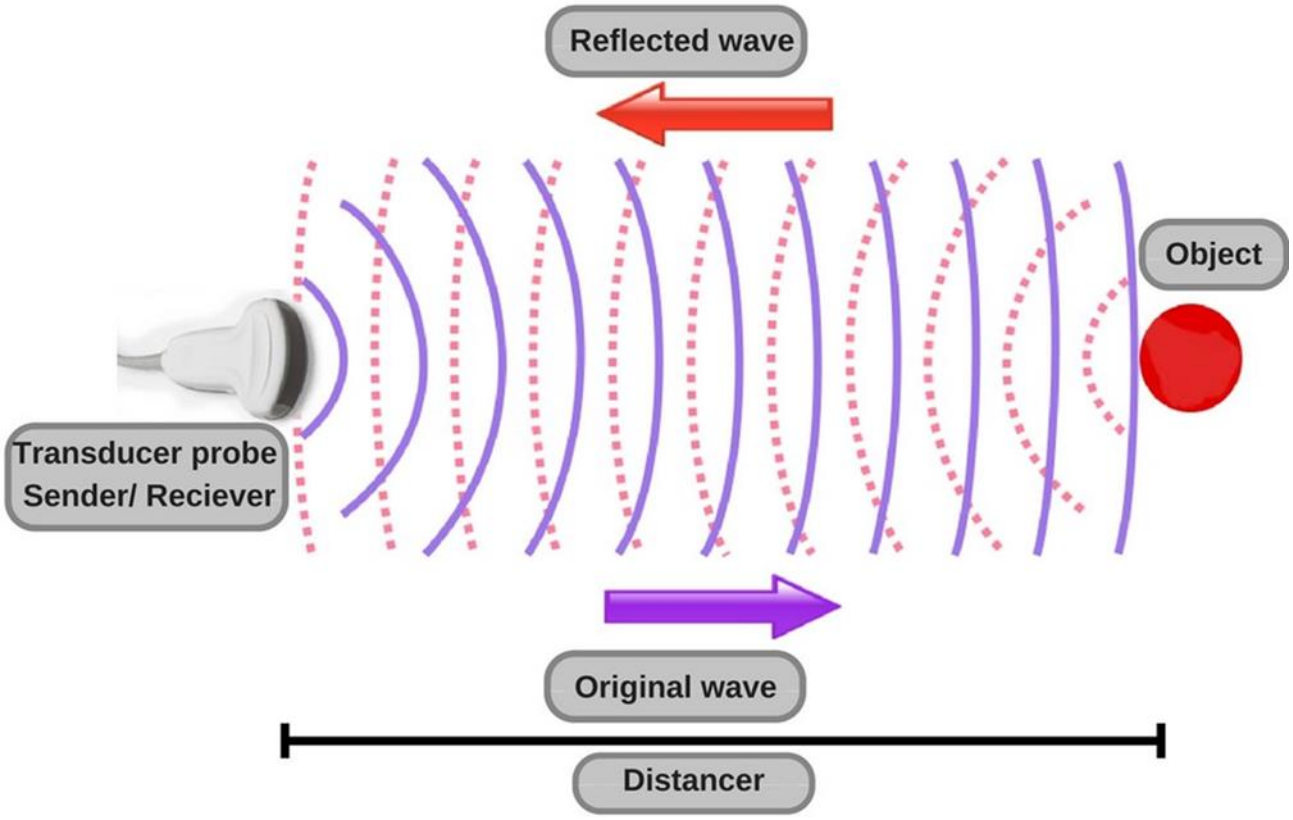
Disadvantages:

1- Bone does not give an MR signal, a signal is only obtainable from bone marrow.
2- Scanning time can be long and is thus demanding on the patient.
3- It is contraindicated in patients with certain types of surgical clips, cardiac pacemakers, cochlear implants and in the first trimester of pregnancy.
4- Equipment tends to be claustrophobic and noisy.
5- Metallic objects, e.g. endotracheal tubes need to be replaced by non-ferromagnetic alternatives.
6- Equipment is very expensive.
7- Bone, teeth, air and metallic objects all appear black, making differentiation difficult.

Ultrasound (US):

Conventional X-ray-generating equipment is replaced by a very high frequency (3.5-10 MHz) pulsed ultrasound beam which is directed into the body from a transducer placed in contact with the skin.

As the ultrasound travels through the body, some of it is reflected back by tissue interfaces to produce echoes, which are picked up by the same transducer and converted into an electrical signal and then into a black, white and grey visual echo picture image, which is displayed on a television screen.



Main indications for ultrasound in the head and neck:

1- Evaluation of swellings of the neck, cervical lymph nodes or the major salivary glands. Ultrasound is now regarded as the investigation of choice for detecting solid and cystic soft tissue masses.
2- Detection of salivary gland and duct calculi.
3- Assessment of blood flow in the carotids and carotid body tumors.
4- Assessment of the ventricular system in babies by imaging through the open fontanelles.
5- Therapeutically, in conjunction with the newly developed sialolithotripter, to break up salivary calculi into approximately 2 mm fragments which can then pass out of the ductal system so avoiding major surgery.
6- Ultrasound-guided fine-needle aspiration (FNA) biopsy.

Advantages of ultrasound:

1- They are generally painless and do not require needles, shots or cuts.
2- Patients aren't exposed to ionizing radiation, making the procedure safer than diagnostic techniques such as X-rays and CT scans. In fact, there are no known harmful effects when used as directed by your health care provider.
3- Ultrasound captures images of soft tissues that don't show up well on X-rays.

4- Ultrasounds are widely accessible and less expensive than other methods.

Disadvantages of ultrasound:

1. Ultrasound has limited use in the head and neck region because sound waves are absorbed by bone. Its use is therefore restricted to the superficial structures.
2. Technique is operator dependent.
3. Images can be difficult to interpret for inexperienced operators because image resolution is often poor.
4. Real-time imaging means that the radiologist must be present during the investigation.

REFERENCES:

1. Zhang Y, Zhang L, Zhu XR, Lee AK, Chambers M, Dong L: Reducing metal artifacts in cone-beam CT images by preprocessing projection data. International Journal of Radiation Oncology* Biology* Physics 2007, 67(3):924-932.
2. White SC, Pharoah MJ: Oral radiology: principles and interpretation: Elsevier Health Sciences; 2014.
3. Pauwels R, Stamatakis H, Manousaridis G, Walker A, Michielsen K, Bosmans H, Bogaerts R, Jacobs R, Horner K, Tsiklakis K: Development and applicability of a quality control phantom for dental cone-beam CT. Journal of Applied Clinical Medical Physics 2011, 12(4).