Cone Beam CT (CBCT) scanners

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INTRODUCTION: Cone Beam CT (CBCT) scanners are a type of medical imaging equipment that uses X-rays to capture detailed three-dimensional (3D) images of a specific region of the body. They are particularly valuable in dentistry, ear, nose, and throat (ENT) surgery, and orthopedics due to several advantages over traditional CT scanners(1-rasm).

1-rasm.Cone Beam CT Scanner

X-ray source:

• **Type:** Unlike traditional CT scanners that use a narrow fan beam, CBCT scanners utilize an X-ray source that generates a cone-shaped beam. This allows for capturing a larger area of interest in a single rotation.

• **Parameters:** The X-ray source operates within a specific range depending on the manufacturer and desired image quality. It typically falls within 60-120 kVp (kilovolts peak) for voltage and 1-15 mA (milliamperes) for current.

Detector:

• **Types:** CBCT scanners can employ two main detector types:

Flat-panel detector: This is a digital detector similar to those used in digital X-rays. It offers high resolution and faster scan times.

Rotating detector array: This detector rotates with the X-ray source,

capturing data from multiple angles simultaneously. It may be less common but can provide wider field-of-view for certain applications.

Gantry:

• **Movement:** The gantry is a mechanical structure that rotates the X-ray source and detector around the patient's head or targeted area. This rotational movement allows for capturing X-ray projections from various angles.

Collimator:

• **Function:** The collimator acts like a filter, shaping the cone-shaped X-ray beam into a defined size and field-of-view. This helps control the radiation exposure to the patient and ensures the beam focuses on the area of interest. Different collimator sizes are available depending on the scan requirements.

Computer System:

• **Reconstruction:** The captured X-ray projections from various angles are transmitted to a powerful computer system. Advanced algorithms are used to reconstruct the 2D images into a high-resolution 3D digital model.

• **Software:** CBCT scanners come with specialized software for image analysis, manipulation, and generation of different 3D views. This allows dentists, surgeons, or other medical professionals to examine the 3D model in detail for diagnosis and treatment planning.

Additional characteristics:

• **Field-of-view (FOV):** This refers to the diameter or area covered by the X-ray beam within the patient. Different CBCT scanners offer varying FOV options depending on the intended application (e.g., full jaw scan vs. single tooth).

• **Voxel size:** This defines the resolution of the 3D image. Smaller voxel sizes result in sharper and more detailed images but may require higher radiation doses.

• **Scan time:** CBCT scans are known for their speed compared to traditional CT scans. Scan times typically range from a few seconds to a minute depending on the chosen FOV and resolution.

Advantages of CBCT scanners over traditional CT scanners:

CBCT scanners offer several advantages over traditional CT scanners, making them a valuable tool in various medical applications. Here's a breakdown of the key benefits:

- **Lower radiation dose:** This is a significant advantage, particularly for procedures frequently performed on younger patients or those requiring multiple scans. CBCT scanners utilize a more focused cone-shaped beam and advanced detectors, significantly reducing radiation exposure compared to the broader fan beam used in traditional CT scans.

- **Lower cost:** CBCT scanners are generally less expensive to purchase and operate compared to traditional CT scanners. This makes them more accessible for smaller medical facilities and dental practices.

- **Faster scan times:** CBCT scans are much quicker than traditional CT scans. A typical CBCT scan can be completed in seconds or minutes, while a CT scan may take several minutes to ten minutes or more. This faster scan time improves patient comfort, especially for children who may struggle to remain still for extended periods.

- **Simpler operation:** CBCT scanners are often designed to be user-friendly and require less technical expertise to operate compared to traditional CT scanners. This allows for faster patient throughput and potentially reduces operational costs.

- **Targeted field-of-view:** CBCT scanners can focus on a specific region of interest, minimizing unnecessary radiation exposure to other parts of the body. This targeted approach is particularly beneficial in dentistry and ENT procedures.

- **Image quality:** While traditional CT scanners offer high-resolution images, CBCT scanners can provide detailed 3D information of bones, soft tissues, and nerves in the targeted area. This detailed information is crucial for precise diagnosis and treatment planning in various specialties.

In summary, CBCT scanners offer a balance of lower radiation dose, faster scan times, lower cost, and good image quality, making them a preferred choice for many dental, ENT, and orthopedic applications.

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