Changing trend from CT to CBCT in maxillofacial radiology

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Abstract

Imaging is an important diagnostic adjunct to the clinical assessment of the dental patients. Since the discovery of x-rays, with various array of imaging modalities, dental radiology has played a revolutionary role in determining diagnosis, treatment plan and prognostic value of various human diseases. Numerous efforts have been made towards 3D radiographic imaging like computed tomography (CT) has been available. Its application in dentistry has been limited because of cost, access and dose consideration. The introduction of cone beam computed tomography (CBCT) specifically dedicated to imaging the maxillofacial region heralds a true paradigm shift from 2D to 3D approach to data acquisition and image reconstruction. This new generation scanner provides a complete 3D view of the maxilla, mandible, teeth and supporting structure with relatively high resolution and low radiation exposure to the patient. This paper intends to reviews the two imaging modalities of maxillofacial region with description of advantages and limitations over each other.

Keywords: CT, CBCT, Maxillofacial imaging.

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Introduction

Imaging is an important diagnostic adjunct to the clinical assessment of the dental patients. Since the discovery of x-rays, with various array of imaging modalities, dental radiology has played a revolutionary role in determining diagnosis, treatment plan and prognostic value of various human diseases.[1] The introduction of cone beam computed tomography (CBCT) specifically dedicated to imaging the maxillofacial region heralds a true paradigm shift from 2D to 3D approach to data acquisition and image reconstruction.[2] This new generation scanner provides a complete 3D view of the maxilla, mandible, teeth and supporting structure with relatively high resolution and low radiation exposure to the patient.[3]

In 1967 first CT scanner was developed by Sir Godfrey N. Hounsfield and different generations were introduced with various modification in improving image quality and reducing radiation dose, but after this there are some limitations of CT in the maxillofacial imaging and to overcome this CBCT imaging modality developed in 1982 with comparatively greater efficacy in the maxillofacial radiology.[2]

Principle of CT & CBCT

In its simplest form a CT scanner consists of an x-ray tube that emits a finely collimated, fan-shaped x-ray beam directed through a patient to a series of scintillation detectors or ionization chambers. These detectors measure the number of photons that exit the patient. This information can be used to produce a cross-sectional image of the patient. The final image set consists of a series of contiguous or overlapping axial images, made at right angles to the long axis of the patient's body. These two-dimensional slices are cross sections, typically 1 mm thick.[5]

Cone-beam scanners use a two-dimensional digital array providing an area detector rather than a linear detector as CT does. This is combined with a three-dimensional (3D) x-ray beam with circular collimation so that the resultant beam is in the shape of a cone, hence the name "cone beam." Because the exposure incorporates the entire region of interest (ROI), only one rotational scan of the gantry is necessary to acquire enough data for image reconstruction.[4] CBCT produces an entire volumetric dataset from which the voxels are extracted. Voxel dimensions are dependent on the pixel size on the area detector. Therefore CBCT units in general provide voxel resolutions that are isotropic - equal in all three dimensions.[5]

Applications of CT

- Investigations of intracranial diseases including tumors, hemorrhage, and infarcts.
- Assessment of fractures involving – Orbits and nasoethmoidal complex, Cranial base, and Cervical spine.
- Tumor staging assessment of site, size and extent of benign and malignant tumors affecting

Maxillary antra, Base of the skull, Pterygoid region, Pharynx and Larynx
- Investigations of tumors and tumor like discrete swellings intrensic and extrensic to the salivary glands.
- Investigations of Temporomandibular Joint.
- Preoperative assessment of maxillary alveolar bone height and thickness before inserting implants.[5]

Applications of CBCT

The CBCT has revolutionized the imaging of the maxillofacial region significantly in time that it has got a very wide range of applications in all the fields of dentistry ranging from
- Diagnosis to the treatment planning in implantology
- Oral and Maxillofacial Surgery
- Craniofacial fractures
- Assessment of location of Inferior Alveolar Canal
- Temporo-Mandibular Joint assessment
- Orthodontics, Endodontics, Periodontics
- Cone Beam Computed Sialography of Sialolith and
- Radiotherapy by CBCT[6,7,8,9]

Advantages of CT

Structural relationships of hard and soft tissues can be observed directly. The ability to rotate images and to add or subtract structural components permits relationships to be studied. Contiguous structures can be separated and normal hidden surfaces examined in detail. Accurate linear and volumetric measurements can be made. It eliminates superimposition of images of structures outside the area of interest.[5]

Limitations of CT

The effect of blurring is much greater than in conventional radiographic systems. Its application in longitudinal monitoring of implant prosthesis is limited and contraindicated because of the image artifact created by metals that would obscure the information. Metallic objects such as fillings produce marked streak artifacts across the CT image. The equipment is very expensive. There is inherent risks associated with IV contrast agents.[5]

Advantages of CBCT

CBCT equipment occupies less room space compared to conventional CT machine. The cost of the CBCT machine is half of the conventional CT. High Speed scanning. It acquires all projection images in a single rotation. Low Patient Radiation Dose: Published reports indicate that the effective dose (2005 International Committee on Radiation Protection) for various CBCT devices ranges from 52 to 1025 microsieverts (μ Sv) depending on the type and model of CBCT equipment and imaging protocol used. These values are approximately equivalent to 4 to 77 digital panoramic radiographs (approximately 13.3 μ Sv). CBCT imaging produces images with sub millimeter isotropic voxel resolution, which achieve accurate level of spatial resolution for maxillofacial imaging. Images of the patient can be acquired in sitting, standing or supine position.[10]

Limitations of CBCT

Image Noise there is a large portion of the photons undergo Compton scattering interactions and produce scattered radiation. This additional recorded x-ray attenuation, reflecting nonlinear attenuation, is called *noise and contributes* to image degradation. Adequate soft tissue contrast cannot be obtained at relatively low doses applied for maxillofacial imaging resulting in Poor Soft Tissue Contrast. CBCT due to its high areas of attenuation image artifacts such as streaking, shading, rings and distortion most commonly occurs which interferes with image details.[11,12]

Advantages of CT over CBCT

Investigation of intracranial disease including tumours, haemorrhage and infarcts can be evaluated on CT. Investigation of suspected intracranial and spinal cord damage following trauma to the head and neck. Tumour staging assessment of the site, size and extent of tumours, both benign and malignant. Investigation of tumours and tumour-like discrete swellings both intrinsic and extrinsic to the salivary glands.[5,9]

Advantages of CBCT over CT

CBCT is capable of providing sub-millimeter resolution in images of high diagnostic quality, increased precision, with short scanning time (10-70 Sec) and radiation dosage reportedly up to 15 times lower than those of conventional CT scans. CBCT has a wide range of applications in dentistry ranging from the field of Orthodontics, Prosthodontics, Periodontics, Endodontics, Oral and maxillofacial surgery and maxillofacial pathology and Implantology. CBCT has got innumerable advantages like less expensive equipment, radiation dose, room space, time taken for imaging compared with conventional CT. [6,7,8,10]

Conclusion

The introduction of CBCT imaging for maxillofacial region has opened up new vistas for the use of 3D imaging as a diagnostic and treatment planning tool for Orthodontists, Periodontists, Implantologists, ENT Physicians and Oral & Maxillofacial surgeons. CBCT allows the creation in real time of images not only in the axial plane but also 2D images in the coronal, sagittal and even oblique or curved image planes. CBCT has often been described as the "gold standard" for imaging the oral and maxillofacial area and will no doubt become a part of the everyday life of most practices in the coming decades.

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