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International Journal of Current Research
Vol. 8, Issue, 10, pp.40655-40658, October, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

GUIDELINES FOR CONE BEAM CT FOR MAXILLOFACIAL REGION

[1,*]Dr. Sandhya Jain and [2]Dr. Neetu Sharma

[1]Prof and Head, Department of Orthodontics, Govt. College of Dentistry, Indore
[2]PG Student, Department of Orthodontics, Govt. College of Dentistry, Indore

ARTICLE INFO

Article History:
Received 23rd July, 2016
Received in revised form
24th August, 2016
Accepted 04th September, 2016
Published online 30th October, 2016

Key words:
Artifacts,
CBCT,
Radiation dose and risk,
X- Ray.

ABSTRACT

CBCT is a recent technology using low dose of X- ray in comparison to CT and have high spatial resolution which gives image high contrasting structures. Evidence-based guidelines on how and when to use of CBCT have been developed by a Multidisciplinary team consisting of dentists, dental radiologists, medical physicists and dental specialists. Provisional guidelines were developed in 2009 (SEDENTEXCT 2009) and Final guidelines in 2011which were again reviewed in 2012.

Citation: Dr. Sandhya Jain and Dr. Neetu Sharma, 2016. "Guidelines for cone beam CT for maxillofacial region", *International Journal of Current Research*, 8, (10), 40655-40658.

INTRODUCTION

Imaging is an important diagnostic tool along with clinical assessment of the patient. Application of CT in dentistry has been limited because of dose considerations. Numerous efforts have been made toward 3D radiographic imaging in dentistry.
Introduction of cone-beam computed tomography (CBCT) leads a true paradigm shift from a 2D to a 3D approach to data acquisition and image reconstruction in dentistry

CBCT machine

CBCT machine have an X-Ray source which is cone-shaped and a detector which rotate about 180°around the patient's head. Thus divergent pyramidal X-Ray beam is directed through the area of interest. This captures 2D projection images, referred to as projection data, raw data, basis projections, or basis frames. The Projection data are reconstructed into the real images of CBCT. Reconstruction times (less than 5 min) vary depending on the acquisition parameters (voxel size, FOV, number of projections), hardware and software.

Corresponding author: Dr. Sandhya Jain,
Prof and Head, Department of Orthodontics, Govt. College of Dentistry, Indore.

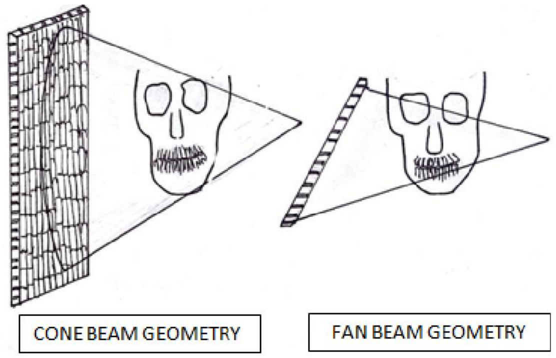
CBCT varies from a traditional medical CT, where there is a fan-shaped x-ray beam in a helical progression to acquire individual image slices of the FOV, then stacks the slices to obtain a 3D representation. Each slice requires a separate scan and separate 2D reconstruction. Current cone-beam machines scan patients in three possible positions:

- Sitting,
- Standing, and
- Supine

Limitations of CBCT

Clarity of CBCT images is affected by artifacts, noise, and poor soft tissue contrast.

Artifacts is the any distortion or error in the image. X-ray beam artifacts- x-ray beam have Inherent polychromatic nature of the projection. Beam hardening occur when lower energy photons are absorbed in preference to higher energy photons that leads to increases in mean energy of X-Ray and create artifacts. These artifacts are more pronounced on CBCT images than CT as CBCT use less Kvp. In clinical practice, it is advisable to reduce the FOV to avoid area of metallic dental restorations and implants.



CBCT manufacturers have also introduced artifact reduction technique algorithms within the reconstruction process.

Patient-related artifacts

Patient motion can cause misregistration of data and results in unsharpness in the reconstructed image. This unsharpness can be minimized by using a head restraint and as short a scan time as possible.

Scanner-related artifacts

These artifacts are circular or ring-shaped, resulting from imperfections in scanner detection or poor calibration resulting in circular repetitive readings at angular region of the detector.

Cone beam–related artifacts

Beam projection geometry of the CBCT produce three types of artifacts:

- Partial volume averaging,
- Undersampling, and
- Cone-beam effect.

Partial volume averaging

It occurs when the selected voxel resolution of the scan is greater than the spatial or contrast resolution of the object to be imaged. So pixels are not representative of the tissue or boundary and image may present with a ‘‘step’’ appearance at boundary.

Under sampling

Occurs when less number of basis projections are used for reconstruction of 3D image. This leads to mis-registration and noisier images. When resolution is very important, this type of artefact is minimized by using all of the basis projection images.

Cone-beam effect

Image distortion because of cone shaped X ray source as the outer row detector pixels record less attenuation. More information is registered by central detector pixels. This results in image distortion, streaking and peripheral noise. This is minimized by various methods of image reconstruction. Clinically, it is minimized by positioning the region of interest adjacent to the horizontal plane of the x-rays and collimation of the beam to an appropriate FOV.

Image noise and Poor soft tissue contrast

X ray shows Compton scattering. Scattered radiation is produced in all directions and is recorded by pixels on the cone-beam area detector, which affects the actual attenuation of the subject. This additional recording of X-ray attenuation is called noise. Scattered radiation significantly reduces contrast of the cone-beam system.

Basic terminologies related to radiation

Radiation dose and risk

Term dose and exposure are widely used. Dose is measured for particular tissue or organ or for all body and Exposure refers to equipment setting.

Exposure shows radiation exposure to patient by the machine. Exposure refers to equipment setting.

Radiation absorbed dose: Amount of X-ray for radiation actually absorbed by the patient. Dose is measured for particular tissue or organ or whole body.

Effective dose: Effect of same type radiation of different body parts.

Effective dose is calculated by

Energy absorbed per unit mass by organ × weighing factor.

TERNINOLOGIES RELATED TO RADIATON

UNIT OF MEASURE MENT	DEFINATI ON	SI UNIT	TRADITIO NAL UNIT	IMPORTAN CE
Exposure	Measure the radiation quantity, capacity of radiation to ionise air.	Coulomb/ kilogram (C/kg)	Roentgen (R)	Basically show exposure of radiation on patient
Absorbed dose	Energy absorbed by any type of ionising radiation per unit mass of any type of matter	Gray (Gy)	Rad (radiation absorbed dose)	Amount of X-ray/ radiation actually absorbed by patient
Equivalent dose	Used to compare the biological effect of different type radiation on a tissue or organ	Sievert (Sv)	Rem (Roetgen equivalent man)	Biological damage done by different type of radiation
Effective dose	Used to estimate the risk in humans	Sievert (Sv)	–	Effect of same type radiation of different body part

Radiation risk

X rays are electromagnetic radiation having wavelength 10^{-9} to $10^{-13m.}$ They have high energy high and penetrating power. Due to high energy transfer to matter causes harms to body of expose person. Radiation risks are age dependent, being highest for the young and lowest for elder. All age risk for female are slightly higher and those for males slightly lower. X- Rays are electro-magnetic radiation. Electro-magnetic radiation have wave length from 10^{-13} to 10^{3} m. Importance of this is that x- ray has high energy, high penetrating power and high energy transfer to matter by ionisation. Due to ionisation property it cause harm to body of exposed person.

Range of effective dose from dental CBCT (Sv)

Studies are divided into "dento-alveolar" for imaging of the lower and upper jaws (small and medium FOV ≤ 10cm) and "craniofacial imaging" form axillofacial region (large FOV ≥10cm).

Effective dose from dental imaging tech. in micro Sv

S. No	Dental imaging technique	Effective dose(µSv)
1	IOPA	1-8.3
2	Panoramic radiology	3.85-30
3	Lateral radiology	2-3
4	CBCT- small	34+/-14
5	CBCT- medium	88+/-70
6	CBCT- large	131+/-91
7	CBCT- maxilla	100- 3324
8	CBCT- mandible	364-1202

Basic principles for appropriate use of CBCT

There are some basic guidelines to use a sub dental CBCT to avoid its inappropriate use

- CBCT should be carried out after history and clinical examination and it should justify that that the benefits outweigh the risks and add new information to aid the patient's management.
- CBCT is used when low dose conventional radiography cannot answer adequately
- CBCT should not be repeated "routinely" without assessment a new risk/benefit.
- For CBCT examinations, the referring dentist must supply sufficient clinical information for Justification of process.
- For evaluation of soft tissues conventional medical CT or MR better rather than CBCT.
- Volume sizes should be smallest and compatible with the clinical situation to reduce radiation dose.
- For accurate positioning light beam markers should be used
- CBCT resolution compatible with adequate diagnosis with the lowest achievable dose should used.
- A quality assurance program should be implemented for CBCT facility, including equipment, techniques and quality control procedures.
- CBCT equipment should undergo regular routine tests to ensure radiation protection.
- Persons involved with CBCT should receive theoretical and practical training for radiological practices and radiation protection.
- Continuing training after qualification are required, when new CBCT equipment used.
- Dentists who have not previously received any training should undergo a period of additional training for use of CBCT.
- For dento-alveolar and non-dento-alveolar area CBCT images, clinical evaluation should be made by DMF Radiologist, Medical Radiologist or trained general dental practitioner

Indications in Dentistry

As with any X-ray exposure, CBCT entails a risk to the patient. Routine CBCT use is unacceptable. All CBCT must individually justified potential benefits to the patients outweighing risks and its record submitted. CBCT examinations should potentially add new information to aid the patient's management. CBCT should performed after detailed clinical examination.

CBCT for developing dentition

Applications of dental CBCT in assessment of the developing dentition divided into two broad headings:

- Localized application to answer a specific question.
- Generalized application for examination of the entire dento-facial region.

Localised application

Assessment of the position of an un-erupted tooth, particularly where the tooth is impacted (including consideration of resorption of an adjacent tooth) Ex – impacted maxillary canines after 10 yr of age suspected of resorbing incisor roots are having undergone (Walker *et al*., 2005). 3D information of CBCT will identify resorption of roots more effectively specially labial and lingual surface than conventional intraoral radiographs.

For evaluating impacted tooth smallest volume size should be use reduced radiation dose. Use of CBCT units for large volumes (craniofacial CBCT) requires very careful justification and is generally discouraged. 3D information is also used to determine the amount of bone needed for adequacy of bone filling during bone grafting (Oberoi *et al*., 2009; Shirota *et al*., 2010). Smallest volume size compatible with the situation should be selected because of reduced radiation dose.

Temporary orthodontic anchorage using "mini-implants"

CBCT used to measure the available bone thickness for placing temporary anchorage devices (TADs).Jung *et al* (2010) found that three dimensional imaging was only needed in rare cases of borderline dimensions to identify optimal position of mini-implant and to avoid damage to roots.

Generalized application

Some clinician use large FOV as routine investigation for orthodontics related assessment of entire facial skeletal. However, no scientifically valid evidence was identified to support the routine use of large volume CBCT at any stage of orthodontic treatment. For complex cases of skeletal abnormality, particularly those requiring orthognathic surgery large volume CBCT may be justified in planning the definitive procedure at 16 years or over, particularly where MSCT is the current imaging method of choice. Amongst the justifications to use CBCT rather than conventional radiography is that it allows accurate establishment of "boundary conditions" (Kapila *et al*., 2011) in patients with Bucco-lingually narrow alveolar bone, compromised periodontal or gingival anatomy, movement of a tooth may involve translocation past another tooth or obstruction

Restoring the dentition

Occlusal caries detection is better with CBCT. The diagnostic accuracy of CBCT and conventional radiograph is same for detection of proximal caries.

Periodontal assessment

Limited volume, high resolution CBCT may be indicated for periapical assessment, in some cases. For example if there are positive clinical findings which are not detectable with conventional radiograph. Infra-bony defects and furcation lesions, where clinical and conventional radiographic examinations do not provide the information needed for management

Endodontics

Limited volume, high resolution CBCT may be indicated, for same cases of endodontic treatment

- Where conventional intraoral radiographs provide inadequate information for planning treatment. Ex-Inmulti-rooted teeth.
- When planning surgical endodontic procedures where complication are suspected to arise because of proximity of some important anatomical structures.
- Cases of inflammatory root resorption or internal resorption, where three-dimensional information is important as it might affect the management.
- Where endodontic treatment is complicated by presence of factors, such as resorption, perio-endodontic lesions, perforations and atypical pulp anatomy.

Dental Trauma

- Limited volume, high resolution CBCT is indicated suspected root fracture.

Mandibular Third Molar Removal

- If there is a direct close proximation mandibular third molar to the mandibular canal, and when a decision to perform surgical removal has been made, CBCT may be indicated.

Prosthodontic Implant

- CBCT is indicated for cross-sectional imaging prior to implant placement.
- The advantage of CBCT with adjustable fields of view as compared to MSCT, is greater where the region of interest is a localized part of the jaws.

Soft Tissue Assessment

- For soft tissues assessment MR is better rather than CBCT.

Oral Cancer (Bony Invasion)

- Limited volume, high resolution CBCT may be indicated for evaluation of bony invasion of the jaws CBCT by oral carcinoma when the initial imaging modality used for diagnosis and staging (MR or MSCT) does not provide satisfactory information.

Fracture

- For maxillofacial fracture assessment, where cross-sectional imaging is required, CBCT is indicated as an alternative imaging modality to MSCT.

Orthognathic Surgery

- CBCT is indicated in orthognathic surgery planning, for obtaining three-dimensional datasets of the craniofacial skeleton.

TMJ

Where the existing imaging modality for examination of the TMJ is MSCT, CBCT is indicated as an alternative where radiation dose is shown to be lower.

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