
Oral Health Division
Ministry of Health Malaysia
GUIDELINES ON THE USE OF CONE-BEAM COMPUTED TOMOGRAPHY (CBCT) IN GOVERNMENT DENTAL FACILITIES

MOH/K/GIG/24.2015(GU)

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December 2015

FOREWORD
PRINCIPAL DIRECTOR OF ORAL HEALTH
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Cone-Beam Computed Tomography (CBCT) is a relatively new imaging application and is rapidly being accepted as an imaging modality for diagnosis, treatment planning and follow up in dentistry. The advantages of CBCT includes high spatial resolution, low radiation dose and short scanning time compared to the conventional medical CT machines.

Although the effective dose for imaging techniques using CBCT is higher compared to conventional dental imaging techniques, it is much lower compared to the multi-slice CT. With concerns on radiation safety for patients and operators associated with CBCT, there is a need to enhance the understanding in relation to CBCT usage and to abide to the principle of As Low As Reasonably Achievable (ALARA). It should be noted that CBCT should not be used for 'routine' or 'screening' purposes.

Currently existing guidelines such as the Guidelines on Radiation Safety in Dentistry 2010 has not addressed the application of CBCT on clinical cases. Thus, these guidelines will provide basic guidance on the use of CBCT in dentistry and maxillofacial imaging in Malaysia for dental specialists, dental officers and radiographers.

I thank the working group and reviewers for their commendable efforts and commitment towards formulating these guidelines. I sincerely hope that this document will be useful to all clinicians concerned. Whilst enabling clinicians to keep abreast with the evolution of imaging technology, it also provides guidance on the use of CBCT for optimum patient benefit and better clinical outcomes.

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1. INTRODUCTION

Cone-Beam Computed Tomography (CBCT) is a relatively new dental imaging application which is becoming popular within the dental fraternity. [1] It is rapidly being accepted as an imaging modality for diagnosis, treatment planning and follow up in various fields in dentistry. The advantages of CBCT three-dimensional (3D) volumetric approach of the dental arches and the surrounding hard tissues includes high spatial resolution, low radiation dose [2] and short scanning time compared to the conventional medical CT [3] machines. The evolution of the different CBCT models allows the operator to select the appropriate field of view (FOV) for the desired region of interest and to decide on the exposure parameters which then reduces X-ray radiation on patient. The understanding and responsibility to abide to the principle of As Low As Reasonably Achievable (ALARA) should be emphasized as there are mounting concerns with regards to radiation safety of patients and operators. The ranges of effective dose from various types of imaging techniques [4] are as in Table 1.

[1] Health Protection Agency, Centre for Radiation, Chemical and Environmental Hazards. Guidance on the Safe Use of Dental Cone Beam CT (Computed Tomography) Equipment. November 2010. ISBN 978-0-85951-681-5.

[2] Pauwels R, et al. Effective dose range for dental cone beam computed tomography scanners. *Eur J Radiol* (2011), doi:10.1016/j.ejrad.2010.11.028.

[3] William C Scarfe, Allan G. Farman, Predag Sukovic. Clinical Application of Cone-Beam Computed Tomography in Dental Practice. *J Can Dent Assoc.* 2006. 72(1):75-80.

[4] The SEDENTEXCT project. Radiation Protection: Cone Beam CT for Dental and Maxillofacial Radiology. Evidence based guidelines. 2011 (v2.0 Final)

Table 1: Comparison of Effective Dose from Various Dental Imaging Techniques

Dental Imaging Techniques	Effective dose (µSv)
CBCT unit type: • Dento-alveolar (small and medium FOV) • Craniofacial (large FOV)	 11-674 (median = 61) 30-1073 (median = 87)
Intra oral radiograph	< 1.5
Panoramic radiograph	2.7-24.3
Cephalometric radiograph	< 6
MSCT (Multi-slice CT) maxilla-mandibular	280-1410

Previous guidance provided in Guidelines on Radiation Safety in Dentistry [5] has not addressed the application of CBCT on clinical cases. These guidelines are developed to provide basic guidance on the use of CBCT in dentistry and maxillofacial imaging in government hospitals in Malaysia. In keeping abreast with new findings, these guidelines are based on the European Radiation Protection No. 172 Cone Beam CT for Dental and Maxillofacial Radiology [6] with emphasis on the justification of patient exposure and the importance of patient and staff protection. However, it must be read together with other related guidelines and regulations.

[5] Malaysian Dental Council. Guidelines on Radiation Safety in Dentistry. Second Edition, November 2010.

[6] European Commission. Radiation Protection No. 172. Cone-Beam CT for Dental and Maxillofacial Radiology. Evidence based guidelines. 2012. ISSN 1681-6803.

2. SCOPE

The scope of these guidelines is to address the use of CBCT equipment by specialists, dental officers and radiographers in government hospitals in the country. This also includes dental specialists and dental officers from peripheral clinics who request for CBCT images in the management of their patients.

3. LOCATION

As of 31st December 2014, there is a total of 18 CBCT machines in the Ministry of Health. Eight CBCT units are installed in the dental specialist clinics and the rest are in the radiology department in hospitals (**Appendix 1**). The installation of CBCT scanners in identified locations should abide by the existing rules and regulations of the Atomic Energy Licensing Act 1984 (Act 304) [7] and Guidelines on Radiation Safety in Dentistry, 2010.[5] In general, it follows the safety requirements imposed on the installation of dental panoramic machine.

4. RISKS AND BENEFITS TO USER AND PATIENT

Imaging is essential to determine the presence, nature and extent of disease. It is useful as a guide in treatment planning, monitoring

[7] Engineering Services Division, Ministry of Health Malaysia. Guidelines to Obtain Class C License Under the Atomic Energy Licensing Act 1984 (Act 304). November 2000.

disease progression and assessing treatment efficacy. An integral part of imaging is the exposure of patients and staff to radiation. It should be considered that all radiation exposure is equally harmful to both patients and staff. Thus, clinicians are responsible for the justification of each exposure as well as ensuring protection of patients, operators and others.[4]

5. JUSTIFICATION FOR USE OF CBCT

5.1 The justification for any CBCT examination must be made by demonstrating that such examination has greater potential benefits to the patients, in comparison to its potential risks. The possibility of the CBCT image to add new information for better patient management, as well as, to improve clinical outcomes should be considered prior to the exposure. A record of the justification process made for each patient must be retained.[8]

5.2 When a patient is referred for CBCT examination, the referring clinician must provide sufficient patient history and results of clinical examination to allow for the judicious use of CBCT.

5.3 The selection of CBCT field of view must be justified on an individual basis prior to the CBCT exposure. All findings in the involved structures within the CBCT image must be documented. In the presence of incidental findings with CBCT image, a referral to relevant specialty should be made, whenever necessary for subsequent care of the patient.

[8] American Dental Association Council on Scientific Affairs. The use of cone-beam computed tomography in dentistry. *JADA* 143(8) August 2012. http://jada.ada.org.

5.4 Usage of CBCT machine / unit with only large field of view selections (craniofacial CBCT) has to be very carefully justified and is generally not recommended.

6. CLINICAL INDICATIONS

In general, limited volume, high resolution CBCT offers the best options for imaging of dental conditions as follows:

- **Bony invasion of the jaws**
  CBCT imaging may be indicated for evaluation of bony invasion of the jaws by oral carcinoma, when Magnetic Resonance Imaging (MRI) or Multi-slice Computer Tomography (MSCT) does not provide satisfactory Information.

- **Maxillofacial fracture assessment**
  CBCT may be indicated as an alternative imaging modality to MSCT, when a cross-sectional imaging is necessary and soft tissue detail is not required.

- **Cross-sectional imaging prior to implant placement**
  CBCT is indicated for cross-sectional imaging of the jaws prior to implant placement. The advantage of an adjustable FOV, limits the exposure only to the intended part of the jaw. These scans can also be employed for virtual simulation of the implant placement.

- **Impacted tooth**
  CBCT may be indicated for the localized assessment of an

impacted tooth in close proximity to the inferior alveolar nerve and also to determine if there is any resorption of the adjacent tooth.

- **Pre-surgical assessment for cleft palate**

MSCT is the current imaging method of choice for the assessment of cleft palate, however CBCT may be preferred as the radiation dose is lower.

- **Skeletal abnormality**

For complex cases of skeletal abnormality, in particular those requiring combined orthodontic/surgical management, a large volume CBCT examination may be justified in planning for the definitive procedure.

- **Infra-bony defects and furcation lesions**

CBCT may be indicated in selected cases of infra-bony defects and furcation lesions, where conventional radiographic examinations do not provide the information needed for their management.

- **Periapical assessment**

CBCT may be used for periapical assessment of selected cases, especially when conventional radiographs and clinical signs and symptoms appear contradictory.

- **Surgical endodontic procedures**

CBCT may be indicated for selected cases planned for surgical endodontic procedures. The decision is based on potential complicating factors, such as the proximity of important anatomical structures.

- **Inflammatory root resorption or internal resorption**

CBCT may be indicated in selected cases of suspected or established inflammatory root resorption or internal resorption, where a three-dimensional information is likely to alter the management or prognosis of the tooth.

- **Complicated endodontic treatment**

CBCT may be justifiable for selected cases, where endodontic treatment is complicated by factors, such as resorption, combined periodontal/endodontic lesions, perforations, atypical pulp anatomy and multi-rooted teeth morphology.

- **Pre-surgical assessment of an unerupted tooth**

CBCT may be indicated for the pre-surgical assessment of an unerupted tooth where conventional radiographs fail to provide the information required.

- **Bone information in orthognathic surgery**

CBCT may be indicated to obtain three-dimensional datasets of the craniofacial skeleton, where orthognathic surgery is planned.

- **Examination of the Temporomandibular Joint (TMJ)**

While the existing imaging modality for examination of the TMJ may be MSCT, CBCT may be an alternative as the radiation dose is lower.

- **Examination of paranasal sinuses**

Variation in the radiodensity in the sinuses will indicate the extent of any lesions affecting them.

7. CONTRAINDICATIONS

All CBCT examinations should only be done after a thorough clinical history and examination has been completed and where clearly indicated. CBCT should not be used for 'routine' or 'screening' purposes. CBCT is not indicated as a routine tool for:

a) Orthodontic diagnosis
b) Caries detection and diagnosis
c) Imaging of periodontal bone support
d) Identification of periapical pathosis
e) Demonstration of root canal anatomy

8. REQUISITES FOR CBCT USERS

- All those involved with CBCT usage must have adequate theoretical and practical training for the purpose of radiological practices and relevant competence in radiation protection. This is in line with para 3.1 of the Director General of Health Circular 3/2010 [9] on the competency of the operator in managing imaging equipment.

- When new CBCT equipment is procured, further education and training on use of the equipment is required.

- Dental practitioners who use CBCT equipment and who have not received "adequate theoretical and practical training" should undergo a period of additional theoretical

[9] *Surat Pekeliling Ketua Pengarah Kesihatan Malaysia Bil.3/2010. Keperluan mendapatkan khidmat personel berkelayakan sebagai pengendali radas penyinarab bagi perkhidmatan pergigian di bawah Akta Perlesenan Tenaga Atom(Akta 304) bagi maksud perubatan.*

and practical training certified by academic institution (university or equivalent). Where national specialist qualifications in Dental and Maxillofacial Radiology exist, the design and delivery of CBCT training programmes should involve the Oral and Maxillofacial Radiologist. At present, training is provided by the Faculty of Dentistry, University of Malaya. The core content for the training of dental practitioners involved in CBCT imaging is as recommended by the European Academy of Dentomaxillofacial Radiology [10] and summarized as in **Appendix 2.**

9. STAFF PROTECTION

This section is to be read together with the related section in the **Guidelines on Radiation Safety in Dentistry 2010.**[6]

- It is essential that a qualified expert is consulted over the installation and use of CBCT to ensure that the operator is not exposed to X-ray radiation.

- CBCT equipment should be installed in a protected, enclosed area which has been designated as a Controlled Area.

- Periodic monitoring of scattered radiation and, the safety and functionality of existing radiation barriers should be performed.

[10] Brown J, Jacobs R, Levring Jaghagen E, Lindh C, Baksi G, Schulze D et al. Basic training requirements for the use of dental CBCT by dentists: a position paper prepared by the European Academy of DentoMaxillofacial Radiology. *Dentomaxillofacial Radiology* 2014; 43, 20130291.

10. MEASURES TO REDUCE RADIATION RISK TO PATIENTS

- **Volume size (field of view)**
  The field of view of CBCT unit should be adjustable, so that collimation of CBCT exposure can be performed particularly in clinical cases which only require small to medium size coverage of anatomical sections. Collimation of CBCT exposure will restrict the X- Ray beam only to a region of interest and avoid unnecessary radiation exposure to the patient.

- **Lead thyroid collar**
  In CBCT examination, the use of lead thyroid collar on patient will minimize the radiation absorption to thyroid gland which lies close to the primary beam. Thus, the use of this shielding device is recommended in CBCT examination procedure. Careful positioning of the device is necessary to avoid repeat exposure.

It had been reported that dose reduction to organs outside the region of interest can be achieved by using leaded glasses, thyroid collars and collimation during CBCT exposure. Dose reduction to the brain as well as other organs can be minimized up to 91% by applying collimation alone.[11] *(Note: Collimation is the method of restricting and confining the x-ray beam to a given area)*

[11] AD Goren, RD Prins, LT Dauer, B Quinn, A Al-Najjar, RD Faber, G Patchell, I Branets, DC Colosi. Effect of leaded glasses and thyroid shielding on cone beam CT radiation dose in an adult female phantom. *Dentomaxillofacial Radiology* (2013) 42, 20120260. doi: 10.1259/dmfr.20120260.

11. QUALITY STANDARDS AND QUALITY ASSURANCE

The section is to be read together with the related section in the **Guidelines on Radiation Safety in Dentistry 2010.** [6]

- Calibration of CBCT should include a thorough examination and detailed acceptance and commissioning tests. This is carried out for new units and as routine tests throughout the life span of the equipment. Testing should follow published recommendations (once every two years) and a medical physicist expert should perform this task.[5]

- Dental Specialists carrying out CBCT examinations should perform reject analysis at six months intervals with a minimum target of not more than 5% of CBCT examinations classified as "unacceptable". The aim is to reduce the proportion of unacceptable examinations by 50% in each successive audit cycle.

$\frac{\text{No. of unacceptable images X 100\%}}{\text{Total number of images}}$	=	*Percentage of unacceptable images over a time frame
*Target : less than 5%		

12. REGULATORY REQUIREMENTS

Regulations are in place to ensure that CBCT and the accessories are in a good condition prior to use and complied with the regulatory requirement(s):

a) Atomic Energy Licensing Act 1984 (Act 304)

b) Regulations to Act 304:
   - The Radiation Protection (Licensing) 1986
   - Regulations The Atomic Energy Licensing (Basic Safety Radiation Protection) Regulation 2010
   - The Radiation Protection (Transport) 1989

c) The X-ray equipment must fulfill the standard requirement stated in the Malaysian Standard (MS 838) Code of Practice for Radiation Protection (Medical X-ray Diagnosis), 2007.

13. CONCLUSION

Use of CBCT is gaining momentum as an imaging modality for diagnosis, treatment planning and follow up in various fields in dentistry. Importantly, CBCT users need to be equipped with the basic knowledge associated with this modality. This document will provide the necessary knowledge and guide for appropriate practice in maintaining good and safe radiation procedures with maximum benefit to the patient.

APPENDIX

Appendix 1

Location and Type of CBCT in Government Facilities

No.	Hospital / Clinic	Year of Pro-cureme nt	Brand	Model	FOV SIZE			Operator
					S	M	L	
1	Oral Surgery Department Hospital Tengku Ampuan Rahimah, Klang, Selangor.	2009	J.Morita	Vera View epocs-3D			√	Radiolo-gist
2	Oral Surgery Department, Hospital Selayang, Selangor.	2009	J.Morita	Vera View epocs-3D (x550)	√			Radiolo-gist
3	Pediatric Dental Surgery Pediatric Institute, Hospital Kuala Lumpur.	2009	J.Morita	Vera View epocs-3D	√	√		Dental Special-ist, Den-tal Officer
4	Radiology Department Hospital Sultanah Aminah, Johor.	2009	J.Morita	Vera View epocs-3D	√			Radiolo-gist
5	Radiology Department Hospital Queen Elizabeth, Kota Kinabalu, Sabah.	2009	J.Morita	Vera View epocs-3D	√			Radiolo-gist
6	Oral Surgery Department, Hospital Kajang, Selangor.	2009	J.Morita	Vera View epocs-3D (For 40x80)		√		Radiolo-gist
7	Radiology Department, Hospital Pulau Pinang, P. Pinang.	2009	J.Morita	Vera View epocs-3D (For 40x80)	√			Radiolo-gist
8	Oral Surgery Department, Hospital Putrajaya, Putrajaya.	2010	Planme-ca	Promax 3DS		√		Dental Special-ist, Den-tal Officer
9	Oral Surgery Department, Hospital Umum Sarawak, Kuching, Sarawak.	2010	Planme-ca Romexis	ProMax 3DS			√	Radiolo-gist

No.	Hospital / Clinic	Year of Pro-cureme nt	Brand	Model	FOV SIZE			Operator
					S	M	L	
10	Radiology Department, Hospital Serdang, Selangor.	2013	Planmeca	ProMax 3DS	√			Radiolo-gist
11	Radiology Department, Hospital Kulim, Kedah.	2013	Planmeca	ProMax 3DS	√	√		Dental Special-ist, Den-tal Officer
12	Radiology Department, Hospital Taiping, Perak.	2013	Carestrea m	CS 9300	√			Radiolo-gist
13	Radiology Department Hospital Tuanku Jaafar, N. Sembilan.	2013	Planmeca	ProMax 3DS	√			Radiolo-gist
14	Radiology Department, Hospital Tuanku Ampuan Najihah, N. Sembilan.	2013	Promax 3D Plus	PlanmecaP romax 3D Plus (kvp: 90:mA:kw:1 :26		√		Radiolo-gist
15	Radiology Department, Hospital Raja Perempuan Zainab II, Kota Bharu, Kelantan.	2013	Planmeca	Promax 3D MID			√	Radiolo-gist
16	Radiology Department Hos-pital, Sarikei, Sarawak.	2013	Planmeca	Promax Dimax X-4	√			Dental Special-ist, Den-tal Officer
17	Radiology Department, Hospital Tawau, Sabah.	2013	Planmeca	Promax 3D MID			√	Radiolo-gist
18	Radiology Department Hospital Raja Permaisuri Bainun, Ipoh, Perak	2010	J.Morita	Vera View epocs-3D	√			Radiolo-gist

Appendix 2

Core Contents for Theoretical and Practical Training of Dentist Involved in CBCT Imaging

Type of training	Training content
A) Theoretical training	1. Radiation Physics • How X-rays interact with matter • Biological effects of radiation • Background radiation and its origin • Radiation doses and risks with CBCT 2. Justification and indication for the use of dental CBCT 3. Technical background of CBCT • Construction and function of CBCT equipment • Concept of the imaging chain (from initiating the X-ray exposure to display of the image) • Principles of image detector and its influence on image quality 4. Quality Assurance / Regulations for the use of CBCT • Knowledge of the regulations that direct the use of CBCT in the practitioner's country

Type of training	Training content
	5. Diagnostic quality of CBCT Image • Knowledge of the factors controlling X-ray quantity, quality and geometry and its influence on image quality • Artefacts on CBCT image 6. Interpretation of CBCT images • Principles of reformatting image data • Normal radiological anatomy on CBCT image • Radiological interpretation of disease affecting the teeth, jaws and facial skeleton on CBCT images • Judgment to identify when to refer for a second opinion
B) Practical training	1. CBCT imaging techniques 2. Measures for radiation protection 3. Use of CBCT software 4. Writing a structured radiological report

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ACKNOWLEDGEMENT

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Appreciation is extended to
Dr Noor Aliyah Binti Ismail, Principal Director of Oral Health,
Datuk Dr Khairiyah bt Abdul Muttalib,
former Principal Director of Oral Health,
and all others who have directly or indirectly contributed to
this document. We would also like to thank
Dr Yaw Siew Lian and Dr Savithri a/p Vengadasalam
for proof-reading this document.

Layout:
Pn. Fatimah bt. Rahman

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