

SHORT COMMUNICATION

Basic training requirements for the use of dental CBCT by dentists: a position paper prepared by the European Academy of DentoMaxilloFacial Radiology

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Cone beam CT (CBCT) is a relatively new imaging modality, which is now widely available to dentists for examining hard tissues in the dental and maxillofacial regions. CBCT gives a three-dimensional depiction of anatomy and pathology, which is similar to medical CT and uses doses generally higher than those used in conventional dental imaging. The European Academy of DentoMaxilloFacial Radiology recognizes that dentists receive training in two-dimensional dental imaging as undergraduates, but most of them have received little or no training in the application and interpretation of cross-sectional three-dimensional imaging. This document identifies the roles of dentists involved in the use of CBCT, examines the training requirements for the justification, acquisition and interpretation of CBCT imaging and makes recommendations for further training of dentists in Europe who intend to be involved in any aspect of CBCT imaging. Two levels of training are recognized. Level 1 is intended to train dentists who prescribe CBCT imaging, such that they may request appropriately and understand the resultant reported images. Level 2 is intended to train to a more advanced level and covers the understanding and skills needed to justify, carry out and interpret a CBCT examination. These recommendations are not intended to create specialists in CBCT imaging but to offer guidance on the training of all dentists to enable the safe use of CBCT in the dentoalveolar region.

Dentomaxillofacial Radiology (2014) **43**, 20130291. doi: 10.1259/dmfr.20130291

Cite this article as: Brown J, Jacobs R, Levring Jäghagen 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. *Dentomaxillofac Radiol* 2014; **43**: 20130291.

Keywords: cone beam computed tomography; education; training; guidelines

There has been a rapid uptake of cone beam CT (CBCT) imaging in oral healthcare in Europe. The European Academy of DentoMaxilloFacial Radiology (EADMFR), in keeping with its mission to serve as a resource for imaging in the dentomaxillofacial area, recognizes that

there is a need to specify the training requirements for dentists using CBCT equipment to ensure the protection of patients undergoing this examination, as higher radiation doses are used than in conventional dental X-ray examinations. The working party of the EADMFR has reviewed the current literature, national guidelines and information available to professional organizations to prepare this position paper. The training recommended in this document is not intended as appropriate or adequate training to create “specialists” in dental and

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Received 8 August 2013; revised 9 October 2013; accepted 10 October 2013

maxillofacial radiology (DMFR), nor is it intended to cover training for operators, technicians or radiographers. It is applicable to all dentists who are not specialized in radiology and takes into account the varying roles a dentist may play in the use of CBCT. Throughout this document, the term “dentist” is used to encompass dental practitioners engaged in general dental care and/or specialist practice other than DMFR.

Introduction

Cone beam CT (CBCT) has been available to dentists since the late 1990s and has experienced a massive surge in popularity over recent years. As new equipment has been developed with ever more advanced imaging capabilities, CBCT has come to represent the accepted standard for three-dimensional (3D) hard tissue imaging in DMFR.

The use of ionizing radiation in medical imaging has always had implications in radiation protection for medical staff, public and patients. It has always been advocated that the “as low as reasonably achievable” principle should be followed,¹ and that doses should be kept as low as reasonably practicable, economic and social factors having been considered.² The EADMFR also proposes that as a general rule, the field of view (volume) should be limited to the area of interest, and the report should always cover the full volume.

The increasing availability and use of CBCT now inevitably requires the dentist to evaluate these novel images for their patients. Across Europe, however, there are differences in depth, extent and structure within the DMFR curriculum for undergraduate dentistry, and training comes under differing national governmental restrictions concerning the right to use radiation. Undergraduate curricula have also changed over time, as the importance of acquiring knowledge in DMFR has increasingly been recognized. These are important aspects to consider when developing curricula and preparing courses to include continuing education in CBCT, since prior knowledge will differ between dentists depending on the country and date of qualification. In reality, the majority of current dental practitioners will have received insufficient or no training in interpreting CBCT images, and they will not have been trained to justify or perform scans. This deficiency in dental education, while acknowledging differing baseline training and experience, should be addressed.

Previous reviews of dentists’ attitudes towards the use of ionizing radiation and the selection criteria in dental radiology have shown a need for extension of continuing education courses in conventional two-dimensional imaging.²⁻⁴ Considering that higher radiation doses are used when CBCT examinations are performed,^{5,6} it is even more important that anyone using this technique understands the justification of patient exposure, optimization of patient dose and protection for staff from radiation. Differences will exist in the

level of continuing education required, depending on how a dentist uses CBCT.

DMFR is a registered speciality with formal training curricula in only a few countries in Europe, including Norway, Sweden, UK, Finland and Turkey. Many other countries, however, have more informal specialists, including researchers in the area or physicians specialized in DMFR. In these European countries, a DMFR specialist or a medical radiologist may be required to perform or take responsibility for CBCT examinations, because these examinations are governed by the same restrictions and regulations as multislice medical CT scanning.⁷ However, in most countries throughout Europe, CBCT is generally available to all dentists. In keeping with the general trend in many European countries towards an increasing usage of medical 3D imaging techniques such as CT,^{8,9} it seems very likely that this will be mirrored in dental imaging. It is well recognized that medical imaging has come to represent the largest man-made source of ionizing radiation in developed countries over recent years.⁸ The rapid increase in the numbers of relatively high-dose CT examinations that are performed has resulted in significant consequences for individual patient doses and the collective dose to the entire population.⁸ Risk assessments based on this increased population dose, particularly for paediatric patients, concluded that the cancer risk associated with CT is not hypothetical.¹⁰ Although the effective doses delivered by CBCT in general are considerably lower than those for CT,⁵ its anticipated uptake will undoubtedly result in an increase in the collective dose to the population. Greater emphasis needs to be placed on radiation protection for both patients and staff in dental practice, and more stringent regulations already exist to govern the use of CBCT in many European countries. The increased dose of ionizing radiation brings greater responsibility for justification of CBCT scans, such that a favourable ratio of benefit to risk can be achieved. Yet, even if the justification process is stringent, an inadequate evaluation of the resultant 3D images by dentists, owing to lack of training, remains a concern. Even if undergraduate training in CBCT and its interpretation improves over time, this does not address the deficiencies of dentists in the interim period, which will persist for several years. In the longer term, implementation of well-designed university-based post-graduate training, together with up-to-date basic CBCT training in undergraduate dental education, should result in more widespread acquisition of appropriate skills, both in CBCT justification and image interpretation. As part of post-graduate education, certification of CBCT users should be considered by national bodies responsible for radiation use and safety, who may find guidance in the contents of this document.

These concerns about training a dentist in CBCT led to the preparation of this position paper, which aims to provide a framework of the basic requirements that should be met by a general dentist if he/she (i) prescribes,

- (ii) justifies or (iii) carries out CBCT examinations, or
- (iv) interprets CBCT images.

Background

In January 2009, EADMFR published its *Basic principles for the use of dental cone beam computed tomography*,¹¹ which stated, under Point 18:

“Dentists responsible for CBCT facilities who have not previously received ‘adequate theoretical and practical training’ should undergo a period of additional theoretical and practical training that has been validated by an academic institution (University or equivalent). Where national specialist qualifications in DMFR exist, the design and delivery of CBCT training programmes should involve a DMF Radiologist.”

This statement was reinforced by the SEDENTEXCT working group and has now been ratified and published by the European Commission.⁵ Training in the use of new imaging equipment and techniques is an important part of effective radiation protection. EADMFR wishes to promote optimal CBCT imaging in dentistry within a safe radiation protection environment. The Academy has consulted members from across the European Union and examined the existing guidelines on CBCT usage and training, which are currently available in countries around Europe, and has developed the following position statements on training for CBCT in dentistry. EADMFR supports the International Commission on Radiation Protection principles of radiation protection and would like to promote these in relation to CBCT imaging. The International Commission on Radiation Protection’s key concepts of justification, optimization and dose limitation for radiation protection are each relevant and should be applied to CBCT.

Appropriate training is the basis for effective implementation of these principles. The European Directive¹² requires that member states of the European Union ensure that any individual involved in radiological imaging has adequate and appropriate theoretical and practical training to undertake and, where appropriate, interpret a radiological examination, as well as relevant competence in radiation protection. EADMFR supports the concept that all those involved in all aspects of CBCT imaging should be adequately trained for the role that they play. It is recognized that roles may vary and that training needs to be tailored to the varying roles within the dental team.

EADMFR understands that there is variation among member countries in the availability of specialists in DMFR or radiologists with special knowledge in DMFR and that there are national variations in the clinical practice of dentistry and in current national requirements for further training in new CBCT equipment. EADMFR endorses the core curriculum for training in CBCT recommended by SEDENTEXCT⁵ as an appropriate outline for training, which recognizes differing levels of training requirements depending on the role of the individual.

The aim of this document is to recommend a minimum level and core content (Table 1) of training for dentists involved in CBCT imaging in dental practice within Europe.

Roles and responsibilities

Dentists involved in CBCT may fall into one or more of the following categories, which are recognized as “entitlement roles” by the European Directive. Each role carries specific responsibilities defined by the regulations. In addition, EADMFR’s basic principles¹¹ require that all those involved with CBCT as shown below must have received adequate theoretical and practical training for the purpose of radiological practices and relevant competence in radiation protection.

The Prescriber

A medical doctor, dentist or other health professional who is entitled to refer individuals for medical exposure to a practitioner following further training and in accordance with national requirements. The Prescriber is involved in the justification process at the appropriate level and would need to supply adequate levels of clinical information.

The Practitioner

A medical doctor, dentist or other health professional who is entitled to take clinical responsibility for an individual medical exposure following further training and in accordance with national requirements. The Practitioner undertakes the justification of radiographical exposure, weighing benefit against risk and considering safer alternatives.

The medical physics expert

An expert in radiation physics or radiation technology applied to exposure, within the scope of the Directive, whose training and competence to act is recognized by the competent authorities and who, as appropriate, acts or gives advice on patient dosimetry, on the development and use of complex techniques and equipment, on optimization, on quality assurance, including quality control, and on other matters relating to radiation protection, concerning exposure within the scope of the Directive.¹²

This EADMFR working group also recognizes that a further role will exist in some countries, as defined below.

The Prescriber who reports

A medical doctor, dentist or other health professional who is entitled to refer individuals for medical exposure to a practitioner, in accordance with national requirements, and who reports on the resultant CBCT examination. These prescribers are involved in the justification process at the appropriate level, the need to supply adequate levels of clinical information to the practitioner and the evaluation/interpretation of the delivered examination.

The above roles provide a framework which is commonly used in European countries and may be used when developing new guidelines concerning CBCT. Each country, however, also has domestic regulations, which the following recommendations do not over-rule. These roles above may be interpreted for application in CBCT imaging as follows. A dentist will act either as a Prescriber, when he/she refers a patient to another dental practice or hospital for CBCT imaging, or as a Practitioner, when he/she offers a CBCT imaging service to other dentists, or as both Prescriber and Practitioner if he/she prescribes and performs CBCT imaging. As a Prescriber, the dentist may refer a patient for a CBCT scan, but he/she does not take ultimate responsibility for the radiological exposure, which is the task of the Practitioner. The Prescriber's responsibility is to supply sufficient clinical information so that the Practitioner may justify the examination, and the Practitioner must also decide on optimum exposure protocols for the task. In some countries, legislation may allow the Practitioner to delegate parts of this role to suitable trained staff under written protocols. A clinical evaluation of the image (radiological report) is essential and is mandatory in some European countries. Either the Prescriber or the Practitioner may report on the resultant CBCT examination, depending on national legislation and guidelines, and it is required that they become adequately trained in 3D diagnostic interpretation of the dentoalveolar region and facial skeleton. They should also be aware of anatomy and disease in adjacent structures to be able to judge when to refer the patient for examination to specialists in DMFR or medical radiology. The EADMFR working party recommend that the radiological report is best prepared by the Practitioner, in light of their knowledge of the justification and imaging parameters during examination.

Levels of education

At least two levels of continuous education are necessary for general dentists:

Level 1

A basic level, directed at Prescribers with limited knowledge of CBCT as an imaging modality and radiology in general (*i.e.* education in selection criteria, technology, radiation protection, outcome, interpretation of the examinations and influence on patient treatment).

Level 2

An advanced level directed at Practitioners and all those who report on CBCT imaging. It would include hands-on use of software for optimizing the examinations and in-depth knowledge of justification and interpretation of CBCT examinations, and when consultancy and further referral is necessary.

To attend Level 2, the learning outcomes formulated for Level 1 must be fulfilled. It should be mandatory

that the course (at least at Level 2) is carried out in a venue where sessions of hands-on training can be provided.

Because techniques and knowledge develop over time, it is recommended that refresher courses are attended regularly.

Learning outcomes

The following learning outcomes have partly been developed by the SEDENTEXCT working group.

The following learning outcomes should be achieved, and on completion of the course, the learner should have demonstrated:

Knowledge and understanding

Level 1:

- knowledge of the concept of the imaging “chain” from initiating the X-ray exposure to display of the image
- knowledge of how X-rays interact with matter
- knowledge of biological effects of radiation
- knowledge of background radiation and its origin
- knowledge of the principles of image detectors and their influence on image quality
- knowledge of the selection criteria for intraoral and panoramic radiography and its influence on radiation protection
- understanding of the difference between two-dimensional and 3D imaging
- knowledge of the regulations that direct the use of CBCT in their own country and an overview of differences in Europe
- understanding of the importance of gaining new knowledge by following scientific developments and improvements in diagnostic imaging and technology.

Level 2:

- knowledge of the factors controlling X-ray quantity, quality and geometry and its influence on image quality
- knowledge of the construction and function of CBCT equipment
- understanding of the principles of CBCT radiographical techniques
- understanding of the principles of reformatting image data
- knowledge of selection criteria for examination with CBCT
- knowledge of principles of diagnostics and how diagnostic radiology relates to other diagnostic methods
- knowledge of selection criteria for examination with CBCT
- knowledge of preparation of a structured report.

Table 1 General training content

<i>Instruction type</i>	<i>Role</i>	
	<i>The Prescriber</i>	<i>The Practitioner</i>
	A dentist who refers for a CBCT examination and reviews the images, including the report from the Practitioner, for clinical use	A dentist responsible for performing the CBCT examination (also including the Prescriber who reports the CBCT examination). This person will normally report on the images but may delegate this role to another individual
	<i>Training content</i>	
Theoretical instruction	Justification and referral criteria for dental CBCT ^{5,13} Radiation physics in relation to CBCT equipment Radiation doses and risks involved with CBCT Radiation protection in relation to CBCT equipment, including justification (referral/selection criteria) and relevant aspects of optimization of exposures CBCT equipment and apparatus	Justification and referral criteria for dental CBCT ^{5,13} Radiation physics in relation to CBCT equipment Radiation doses and risks with CBCT Radiation protection in relation to CBCT equipment, including justification (referral/selection criteria) and relevant aspects of optimization of exposures CBCT equipment and apparatus, technical background information CBCT image acquisition, digital imaging and communications in medicine standard and processing Principles of CBCT imaging Use of different CBCT equipment CBCT imaging techniques and measures for dose reduction Use of software to optimize patient dose and image interpretation Quality assurance for CBCT Care of patients undergoing CBCT
Practical instruction		Principles and practice of interpretation of dentoalveolar CBCT images of the teeth, their supporting structures, the mandible and the maxilla up to the floor of the nose (<i>e.g.</i> smaller fields of view) and of the facial skeleton (<i>e.g.</i> larger fields of view) Normal radiological anatomy on CBCT images Artefacts on CBCT images Radiological interpretation of disease affecting the teeth and jaws and facial skeleton on CBCT images Interpretation of a received report
Radiological interpretation		Principles and practice of interpretation of dentoalveolar CBCT images of the teeth, their supporting structures, the mandible and the maxilla up to the floor of the nose (<i>e.g.</i> smaller fields of view) and of the facial skeleton (<i>e.g.</i> larger fields of view) Normal radiological anatomy on CBCT images Artefacts on CBCT images Radiological interpretation of disease affecting the teeth and jaws and facial skeleton on CBCT images Interpretation of anatomy and disease in adjacent structures to the teeth and their supporting structures and of the facial skeleton. Writing a structured radiological report ^{14,15}

CBCT, cone beam CT.

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Skills and ability

Level 1:

- ability to use CBCT equipment
- ability to describe and implement the regulations that direct the use of CBCT
- ability to support staff development in the use of CBCT
- ability to analyse normal anatomical structures of the teeth, jaws and facial skeleton in CBCT images
- ability to recognize anatomy and disease of the teeth and their supporting structures in CBCT images
- ability to search/identify adequate scientific literature.

Level 2:

- ability to recognize malfunctioning of CBCT devices
- ability to perform a quality control programme for CBCT devices
- skills in practical use of software and other measures for radiation protection

- ability to differentiate between findings indicative of normal anatomical structures from those of diseased teeth, jaws and the facial skeleton
- ability to analyse disease and create a report of CBCT images
- ability to identify and critically review adequate scientific literature.

Judgment and stance

Level 1:

- judgment to strive for a minimized radiation dosage to patients and staff
- responsibility for own competence development in the field of DMFR.

Level 2:

- responsibility for staff development in the field of DMFR
- judgment to identify when to refer for a second opinion or over-read.

Practical aspects of course delivery and time requirements

There is a great deal of variation among member nations on the time required for training in CBCT. Almost all members agree that the dentist should build on prior training in radiation protection, radiographical techniques and interpretation gained during undergraduate training. Most countries also recognize the requirement to train in both the theoretical and the practical aspects of CBCT examinations.

Given the content of the learning outcomes and the recommended adequate training (Table 1) specified above, the working party recommends that:

- For Level 1, this cannot be delivered in less than 12 h of theoretical and practical training.
- To attend Level 2, the learner should have passed a Level 1 course successfully.
- For Level 2, this cannot be delivered in less than 12 h of theoretical training and an additional 12 h of training in practical aspects of CBCT.
- For Levels 1 and 2, interpretation would be included at an appropriate level (the theory and principles of interpretation, report preparation and practical exercises in interpretation). For Level 2, it is recommended that, additionally, further case reports are undertaken as case discussions.
- The learning outcomes should be adequately assessed to ensure that these have been achieved. For Level 2, this should include presentation of case reports.

Discussion and conclusion

While CBCT faces increasing application in DMFR, the level of knowledge among dentists, who often operate these sophisticated machines, may not always be sufficient to meet the considerable demands imposed on performing justification, acquisition and, particularly, interpretation of CBCT images. This discrepancy is mainly owing to the relative novelty of the technique and the lack of education received during a dentist's undergraduate studies. Because the dose of ionizing radiation delivered by CBCT is generally much higher than that involved with conventional two-dimensional dental radiographic imaging, correct justification, acquisition and interpretation are fundamental to every CBCT scan. It is important to note, however, that specialists in DMFR, who exist in some European countries, are not explicitly addressed in this article. It is recognized that these specialists have undergone substantial further training, which includes CBCT imaging. Unfortunately, few European countries have established such dental speciality post-graduate programmes or have recognized the speciality at all. Thus, although EADMFR's suggestions are addressed to all dentists involved in any way in CBCT examinations, the main focus of the article is to address the vast majority of European countries without specialist dentomaxillofacial

radiologists, where a general dentist, or any dental specialist outside the field of radiology, refers for CBCT scans or operates CBCT machines.

EADMFR, as the official organization for DMFR in Europe, recognizes the additional educational demands that these techniques pose for the users. This position paper is a direct reaction to these demands, which have become evident over the past few years. It aims to provide basic guidance on training in topics and issues that should be familiar to a dentist referring for, or justifying, CBCT examinations, when operating a machine and when interpreting CBCT images. The discrimination between the different roles that a dentist may have in the process, as suggested by the SEDENTEXCT group,⁵ *i.e.* "Prescriber" and "Practitioner", allows the definition of different requirements tailored to the specific needs of each group. Essential sources for this article were the work of the SEDENTEXCT group and the *Basic principles for use of dental cone beam computed tomography: consensus guidelines of the European Academy of Dental and Maxillofacial Radiology* published in 2009.¹¹ Based on these sources, an expert group within EADMFR developed the requirements and learning outcomes detailed in this article over a 1-year period. The position paper was also internally reviewed by additional experts from the SEDENTEXCT group. Thus, the position paper represents expert opinion from international specialists in DMFR who have already been involved in CBCT training for several years and who have acquired experience in undergraduate and post-graduate CBCT training. The guidance presented here should be viewed as suggestions for minimum training requirements and demands as derived from current knowledge. Of course, these suggestions are not legally binding, nor can they replace national regulations. Rather, this position paper aims to provide a common source of recommendations for all those interested and involved in CBCT imaging. EADMFR recognizes that the educational situation, and status of CBCT knowledge, will change with time. The same applies for experience gained from implementation and application of the information presented here.

In conclusion, this position paper on the basic requirements for the use of CBCT by dentists not specialized in DMFR provides guidance on what knowledge, understanding and training should be expected when a dentist (i) prescribes, (ii) justifies and (iii) carries out CBCT examinations, or (iv) interprets CBCT images. As a position paper, it represents expert opinion developed by a dedicated panel within EADMFR established for this purpose. Future developments, an increasing experience with the technique and any future changes to European regulations require that review and updating of this position paper is undertaken in 5 years' time.

Acknowledgments

The EADMFR working group gratefully acknowledges review and constructive suggestions from Keith Horner and Eric Whaites.

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