Journal of Dental Reports

ISSN: 2583-2255
Bollen CML, et al., 2023-J Dent Rep
Editorial

Cone Beam Computed Tomography in Implant Dentistry- An update

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Receiving Date: 01-04-2023

Accepted Date: 01-20-2023

Published Date: 02-20-2023

Keywords: Cone beam computed tomography(CBCT); Implant dentistry; Guided implantology.

Introduction

In the more than 20 years that cone beam computed tomography (CBCT) has been available in dentistry, a lot has changed. The image quality has been greatly improved by better detectors and extraction algorithms. Moreover, the grading dose has been reduced by using pulsed beams, the possibility to select smaller fields of view and by the optimization of the reconstruction algorithms [1]. Most modern devices have many setting options, unlike the first generations of devices (Figure 1a and 1b). The field of view can be limited to 4x4cm or similar and the milliamperage, the number of basic projections, the spatial resolution, are all adjustable, so that the image quality and dose can be easily influenced. Something that is also required by the applicable guidelines. The devices have also become a lot more affordable over time. Actual equipment can be used for 2D and/or 3D images.

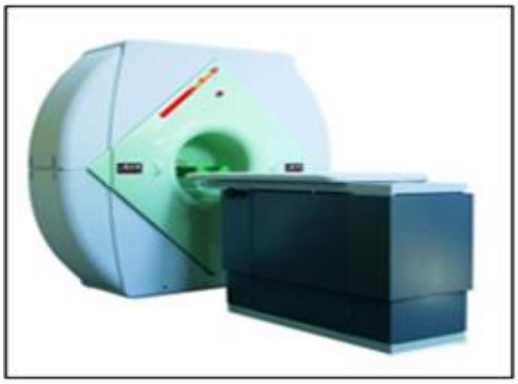

Figure 1a: First generation CBCT equipment.

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DOI: https://doi.org/10.37191/Mapsci-JDR-4(1)-029

Figure 1b: Actual CBCT equipment.

The radiation dose for the patient is still a point of attention. That potentially high radiation dose is also the reason that there is legislation requiring that a dentist who makes CBCT-images, must be additionally trained and certified [2].

In 2012, the European guideline for the use of CBCT in dentistry was published (https://www.sedentexct.eu/content/guidelines-cbct-dental-and-maxillofacial-radiology), partly based on a report by the European Association of Osseointegration (EAO) [3,4]. Since then, much research has been done into the application of CBCT in dentistry and applications have been added but also dropped (Figure 2) [5].

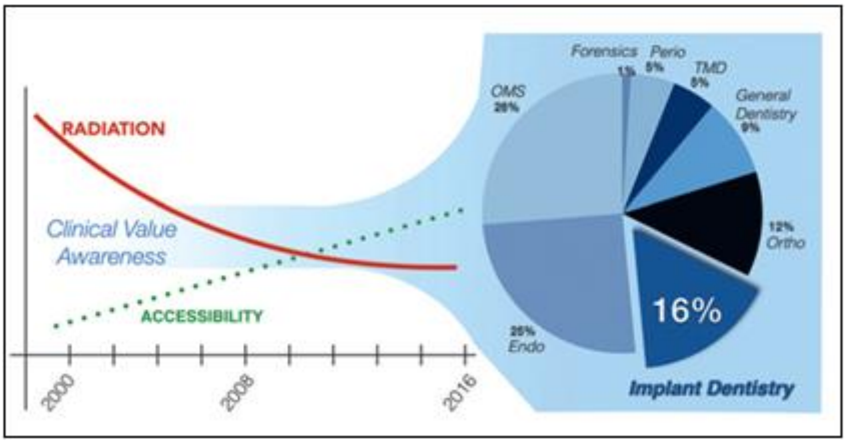

Figure 2: CBCT availability in dentistry over time and indication [5].

Justification

What will never change are the basic principles of radiation protection: justification, optimization (ALARA-As Low As Reasonable Achievable & ALADA-As Low As Diagnostically Acceptable) and dose limits [6].

Justification for the application of ionizing radiation must always be obtained and documented. In a dental context, this means that no X-rays may be made without clinical grounds based on which this potentially harmful form of diagnostics may be used.

These clinical grounds always originate from clinical oral examinations, in which it was found that additional information is required that cannot be obtained other than by means of a supplementary X-ray examination. Quite emphatically, therefore, justification does not imply the choice of a particular recording technique. That choice falls under the second basic principle: optimization.

In 2022, Safety Report No 108 of the International Atomic Energy Agency was published: “Radiation Protection in Dental Radiology” [7]. This report is an extensive update of the aforementioned European directive.

What is striking in this report is the extensive attention given to the 'self-referral' customary in dentistry. The dentist is responsible for conducting a clinical examination and based on this, makes his own justification for subsequently making an X-ray himself [8].

There is no such thing as in medical radiology, for example, where a radiologist who takes a critical look at the justification of the examination. In the safety report, self-referral is seen as undesirable because it can affect objective justification. It is mentioned that the high purchase costs of the CBCT equipment can encourage its excessive use. The latter can be surely counted as malpraxis.

The report therefore makes a strong appeal to the development, application, and assurance of guidelines with up-to-date evidence for the justification of the use of CBCT, but itself only provides a superficial list of possible applications.

Implantological purposes occupy a prominent place in the use of the CBCT. After all, a lot of extremely relevant information can be obtained with this technique:

- the shape and dimensions (height/width) of the alveolar processes;
- the location of anatomical landmarks such as maxillary sinuses, mandibular nerves and the exact location of the roots of neighboring teeth or other implants (Figure 3);
- bone defects and the results of bone augmentation techniques;
- the location and volume of intraoral bone donor sites;
- pathological processes in the jawbone.

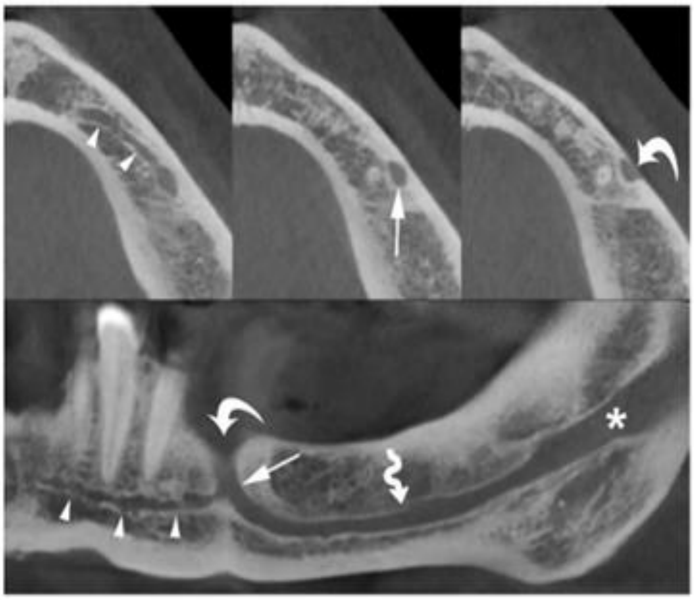

Figure 3: Position of the mandibular nerve on CBCT [9].

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Moreover, distance measurements in CBCT images are accurate and do not require magnification factor calculations. However, the fact that a CBCT can provide this information does not mean that this information should always be obtained with a CBCT: "if clinical examination shows that there is sufficient bone width and conventional X-ray images show that there is sufficient bone height in relation to the anatomical landmarks, the use of a CBCT is not indicated".

Justification is not about whether CBCT is used as a diagnostic tool, but about whether ionizing radiation is used for (additional) diagnostics. If there is a justification for using radiation, the next step is to determine which imaging best matches the required diagnostic information. This is the second basic principle of radiation protection: optimization [10]. In the medical diagnostic radiation application, the acronym ALADA is also used for this: As Low As Diagnostically Acceptable.

Optimalisation

Optimizing the application of radiation means adapting the recording technique and equipment settings to the diagnostic question. Choosing an intra-oral X-ray, panoramic image or CBCT is therefore part of the optimization principle (Figure 4). A CBCT may not be necessary for every implantological case.

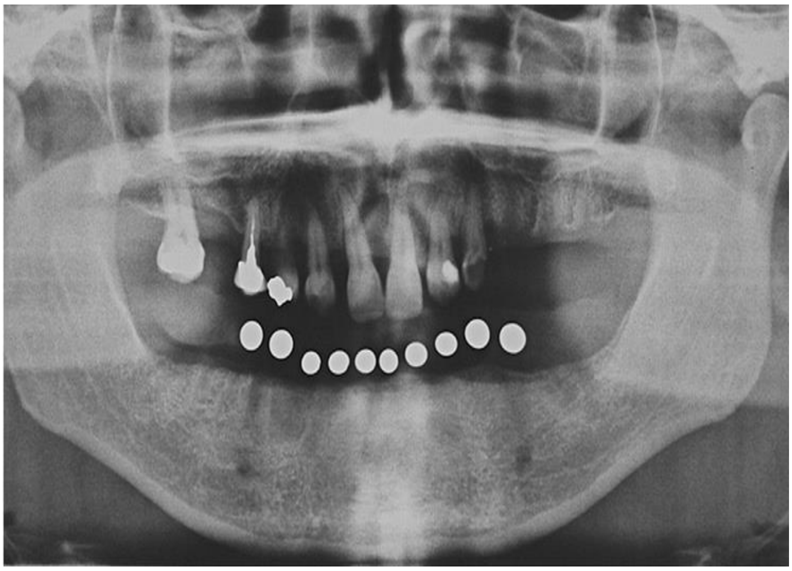

Figure 4: Panoramic image for preimplant assessment of the edentulous mandible [11].

The expected complexity of the implantological case will determine the type of recording technique. CBCT will then be used for more complex implantology and intra-oral and partial panoramic images (and possibly lateral cranial photos) for more standard implantology. The complexity of this banding is of course that it is difficult to objectively define "standard" or "complex", although there is a clear handle for this: namely the ITI SAC classification (Figure 5) [12]. This classification makes a distinction between, standard (green), advanced (yellow) and complex (red) cases.

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Figure 5: The SAC classification tool (https://www.iti.org/tools/sac-assessment-tool).

Guided implantology should also be viewed in the same context. Guided implant placement, using a compelling drilling template designed on basis of a CBCT scan, can provide the necessary support and direction in complex situations that justify the use of CBCT [13].

Unfortunately, many systems for guided implantology still require the scanning of (almost) a complete jaw. When aiming for positioning an implant based on guided implantology, it is therefore always necessary to consider whether the potential advantages of this technique are present. For the time being, these advantages and an efficient use seem to be in situations where, with a high degree of certainty, inferior results will be achieved without guided implantology or are not easy to implement [14].

The relatively large fields of view have a great effect on the radiation dose for the patient. In addition, a CBCT scan for guided implant surgery must have quite good image quality (not too much noise), which will further increase the dose [15]. On the other hand, the image quality of a CBCT scan in situations where no drilling template is used, does not have to be extremely great nor noise-free. The required information is also clearly visible on less "clear" images and the dose can be considerably lower because smaller fields of view can be used, and the lower image quality can be satisfactory.

In addition, the dentist who makes a CBCT scan for guided implantology with a large field of view has the duty to assess and the entire volume (Figure 6). This obligation is often neglected by dentists, who only look at their specific location of interest. Complete analysis and reporting are however obligatory. The scan must therefore not be made only for the technical procedure of manufacturing the drilling template.

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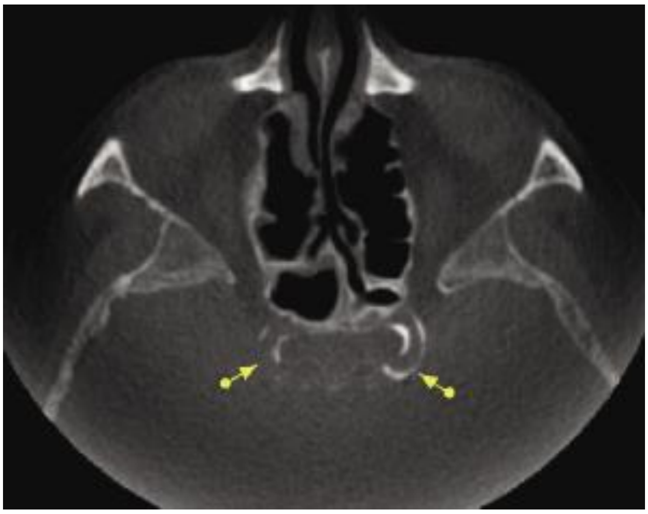

Figure 6: Internal carotid calcifications. Axial CBCT section reveals bilateral, well-defined, high-density ring-shaped opacity (arrows) lateral to the sphenoid sinus [16].

Guided implant surgery in standard implantology situations, partly due to the need for a CBCT scan, does not appear to be effective care because of the radiation burden and high costs.

To optimize this radiation exposure and to support dentists in doing so, dose-reference levels (DRNs) are gradually being introduced in dental radiology [17]. This is already common practice in medical radiology. The idea behind dose reference levels is to lower diagnostic radiation doses [18]. By means of recent research, in a large group of dentists who place implants, information is collected about the usual radiological imaging in a defined implantological situation. Based on that research, an average radiation dose for each type of implantology is determined, which together with scientific evidence forms the basis of the DRN. In dental implantology, this could mean that for a circumscribed implantological situation, for example a single tooth replacement, a DRN is set that makes the use of large volumes, such as in guided implant surgery, impossible. The DRN then directs the clinician towards intra-oral images or collimated panoramic images or small CBCT volumes with a low dose and therefore a relatively high level of noise [19].

Conclusion

The use of CBCT for pre-implant diagnosis has a clear added value, especially in more complex implantological cases. The use of CBCT for guided implantology should be considered if implantological procedures without guided implantology will give inferior results or are not easy to perform.

At all times, the basic principles of justification and optimization (ALARA & ALADA) should be actively used by the clinician, which implicitly also includes thinking about the effectiveness of actions. This will be supported soon by the availability of Doses Reference Levels.

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