

Technical Report

Cone-Beam Computed Tomography

Optimal workflow for all sides

Since its introduction, the range of applications in dentistry using cone-beam computed tomography (CBCT) has been growing steadily: from planning and carrying out implant and endodontic procedures up to monitoring orthodontic and periodontal treatments, state-of-the-art 3D x-ray technology guarantees a high degree of diagnostic certainty in many medical specialties. Yet, besides “pure” CBCT units, modern combination systems in particular feature numerous advantages as regards patient safety, economic efficiency and workflow optimization in interdisciplinary applications, irrespective of whether you are a general practitioner or a specialized physician.

In Germany, too, more and more radiological and dental practices are benefiting from the added value gained with CBCT because it offers high-quality representation of details, minimal artifacts and lower radiation dosage than previous 3D methods such as computer tomography (CT) [1]. One essential advantage of CBCT technology: There aren't any overlaps of structures. This is why, for example, the course of the inferior alveolar nerve and its location in relation to retained wisdom teeth can be assessed more competently with CBCT than with panoramic imaging [2]. Cone-beam computed tomography can be used for basically all necessary dental and medical specialties – from oral and maxillofacial surgery (e.g. clefts, dislocated teeth) to otorhinolaryngology (e.g. sinusitis, impeded nasal breathing) to such dental specialties as implantology (e.g. 3D implant planning), endodontics (e.g. exact localization of root canals), orthodontics (e.g. assessment of bone condition) or periodontology (e.g. diagnosis of periodontal inflammation).

Safety takes precedence – also in CBCT

As with any form of x-ray imaging, CBCT also adheres to the principle that the smallest possible radiation dosage needed to obtain the appropriate informative value for the respective indication (ALARA principle = As Low As Reasonably Achievable) should always be used. The X-Ray Ordinance applicable here in Germany (RöV) regulates the so-called justifiable indications in detail in Section 23: it requires “a determination that the health benefit obtained as a result of the application outweighs the radiation risk for the patient” [3]. Therefore, a fundamental aspect of a CBCT unit is the field of view (FOV), which – always taking into consideration the indication – should be chosen as small as possible and as large as necessary. To that effect, modern CBCT provides a large number of scanning volumes. So, for example, 3D Accuitomo 170 (Morita) offers nine fields of view (from Ø 40 × 40 mm to Ø 80 × 80 mm to Ø 170 × 120 mm) and in this way covers a wide variability of findings. Moreover, a large selection of FOV not only allows many diagnostic options, but also delimits the region to be examined – depending on the medical field – with the effect of reducing the dosage.

With the 3D Accuitomo 170 unit, for example, users can choose between the fields of view without having to forgo consistently high resolution. The radiation exposure remains very low for patients during the scan: based on a specially developed zoom-reconstruction function, it is possible, for example, to reconstruct all detailed images of the relevant regions with a voxel size of 80 µm proceeding from a Ø 80 × 80 mm scan with a voxel size of 160 µm. Accordingly, subsequent detailed images do not have to be retaken, protecting patients from additional radiation exposure.

In addition, there are product developments that reduce radiation by adapting the FOV size: Morita’s Veraviewepocs 3D R100, for example, features an FOV that is adapted to the natural dental arch. This was achieved by replacing the typical cylindrical shape with a convex triangle in the form of a “Reuleaux triangle”. This new feature helps keep the irradiated volume as small as possible and the radiation exposure at a low level (Fig. 1). With Veraviewepocs 3D R100 users have at their disposal altogether eight exposure areas from Ø 40 × 40 mm to R 100 × 80 mm. Hence, a wide range of different diagnostic requirements can be covered: whereas a format of Ø 40 × 40 mm generally is sufficient for surgically removing a

wisdom tooth, larger FOVs are needed to obtain a precise diagnosis of the dental arch. In addition, Veraviewepocs 3D R100 provides a dosage reduction program to minimize radiation as well as a panorama scout, with which the required detailed view of a CBCT scan can be defined. Irrespective of the make, prior to using the device, it is absolutely necessary to take all quality-assurance measures regarding both the technology and the procedure. Moreover, any measures that may reduce the dosage should be taken provided they don't affect the quality of the relevant scan.

Two important aspects: Economic efficiency ...

Amongst other things, the question of economic efficiency gains special relevance when a practice is not specialized in one of the fields named above. This means that the CBCT has to be suitable for the different specialties needed for various indications. An investment makes sense in particular whenever it would contribute towards maintaining the profitability of a practice or expanding the services offered by a practice [4]. The option of having a state-of-the-art 3D x-ray unit can also be used to sharpen the profile of a practice and "to obtain foreseeably better results with the help of better diagnostics" in the corresponding disciplines [5]. In any case, not only the quality of the findings and treatment but also the patient information process will be improved. Acquiring a combination system – such as, for example, Veraviewepocs 3D R100 – may be the most suitable investment for many practices from a purely economical point of view because it provides both 3D images and billable 2D images. Furthermore, it is advantageous as regards space, data archiving and ancillary costs (no film development etc.). Setting up an equipment pool may also prove worthwhile as far as financing is concerned [6]. Besides legal provisions, the FOV selection needs to be considered before acquiring a device, since it needs to be suitable for the specialties offered in the practice. As already explained above, endodontists require smaller FOVs than ear, nose and throat specialists, who need larger volumes. This should also be taken into account if a referral concept is the objective. In this case, the different requirements of the potential referring physicians must be included in the investment planning.

... and workflow

When a system is acquired for interdisciplinary use, i.e. for use in different specialties, joint practices will benefit tremendously, because they can share the unit and pass on findings quickly and easily. Another aspect relevant for use in a practice is that the x-ray system is easy to operate even if it offers many different options. As far as the above-mentioned 3D Accuitomo 170 unit is concerned, a training period of about three days generally is needed to learn how to operate the system [7]. However, in addition to the hardware, modern CBCT systems also score points as regards the software: besides many image-processing options, Morita's i-Dixel, for example, enables the practitioner and his team to provide comprehensive information to patients. Accordingly, both the treatment plan and a complete documentation of the treatment procedure can be shown in detail on the monitor. Amongst other things, i-Dixel includes a drawing function for the mandibular canal and a presentation feature for implant therapy. By exporting it into DICOM format, the treatment plan also can be processed with third-party software – for example, for navigation and planning programs, preparing drill templates and navigation-based procedure planning. When the system is used for referrals, the image data and, consequently, an image-viewing program is needed for the referrals. Morita found an intelligent solution for these aspects in its CBCT and 2D/3D X-ray systems: with the OneVolumeViewer images can be exported easily, and they can be viewed and manipulated on external PCs without installation of the i-Dixel software. Nonetheless, all features of i-Dixel are retained (e.g. for representation, planning, MPR, 3D view).

To sum it up:

In the meantime, CBCT has established itself as advanced x-ray diagnostics in dentistry and particularly in cases “where above all reduced radiation exposure is concerned whilst consciously accepting the resulting system-immanent changes to image parameters, preference should be given to CBCT” [8]. After all, despite the radiation risk, the benefits of CBCT are undisputed for a wide range of dental indication – and these benefits are continuously spreading into further areas of use. The number of individual, joint and referral practices using CBCT systems is rising steadily and so is the number of patients who are benefiting from

uncomplicated and interdisciplinary findings. Patient information, in turn, also profits from the increasing digitalization of dentistry. Patient information, in turn, also profits from the increasing digitalization of dentistry. In view of the requirements posed by a modern practice with respect to safety and economic aspects as well as optimal workflow, diagnostics based on CBCT systems are proving their worth. They increase the diagnostic and patient safety and, moreover, ensure the “future viability” of the equipment in the practice in view of the increasing digitalization of dental medicine – amongst other things by means of numerous hardware and software features as well as the network compatibility of the image data.

Literature

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Figures



Fig. 1: Adapts to the natural dental arch: FOV R100 (Veraviewepocs 3D R100, Morita)