Straumann’s coPeriodontiX:
3-D digital bone measurement using cross-sectional CBCT image data in periodontal issues

Authors: Drs Jonathan Fleiner, Andres Stricker & Dirk Schulze, Germany

_coPeriodontiX (Straumann) is the first software to offer the 3-D evaluation of periodontal bone status using cross-sectional CBCT image data. The aim is the measurement of bone progression prior to, during, and after treatment, as well as monitoring to measure the effectiveness of regenerative treatment. X-ray images have always proven a valuable tool in periodontal diagnostics.\textsuperscript{1,2} Usually 2-D imaging processes, such as bitewing images, intra-oral images of single teeth, or panoramic tomograms, are used for this purpose. All these processes are able to provide important diagnostic pointers, but none of them are without fundamental limitations,\textsuperscript{3} even at a high quality. It is against this background that cone-beam computed tomography (CBCT) has gained increasing importance over the past few years and is now firmly entrenched in certain areas of modern dentistry.\textsuperscript{4,5} In today’s periodontology, CBCT allows for precise answers to a number of diagnostic issues relating to structural bone changes in the dentoalveolar area.\textsuperscript{12} High-resolution and overlap-free imaging of teeth and bone structures, as well as their pathological deterioration, play a major role in diagnostics.\textsuperscript{6-10}

_Principle of radiological bone measurement

As there have been no satisfactory software-based solutions existed to date for standardized use in the periodontological evaluation of cross-sectional data (obtained using CBCT or CT), software was developed in collaboration with Straumann under the name of coPeriodontiX and is now presented for the first time in its current version (8.0) for daily clinical use. The principle of standardised evaluation follows the X-ray six-point measuring principle in analogy to clinical assessment. By positioning a digital 3-D coordinate system centrally on the tooth to be measured, the software automatically generates transverse cross-sections of the tooth (Figs. 1a & b). Using settable, defined landmarks, the distance...
Along the axis of the tooth is measured automatically at six measuring points circumferentially around the tooth (vestibular and oral, with mesial, central and distal measurements in each case) to give a 360-degree evaluation of crestal bone status. The dentino-enamel junction and crestal alveolar bone serve as reference landmarks (Figs. 2a & b). In the case of multiple-rooted teeth, any possible pathological furcation involvement can be clearly evaluated using a special 360-degree panoramic view and by metrically measuring the degree of furcation involvement (Fig. 3). All findings can be presented individually in graphic or table format as desired (Figs. 4a & b).

_Imaging processes in dentistry: 2-D versus 3-D_

The main disadvantage of conventional 2-D image processing is the 2-D display of 3-D anatomical structures. Important morphological aspects and their pathological changes to the tooth-supporting alveolar ridge can only be detected at advanced stages of deterioration, or perhaps not at all, owing to overlapping images. The amount of bone available can only be determined with a certain degree of accuracy in the approximal spaces. The detection and quantitative determination of double- to triple-walled bone defects is often a diagnostic challenge, even in the case of high-quality X-ray images. In this context, coPeriodontiX is intended to be a valuable tool that allows precise and standardised evaluation of 3-D cross-sectional images as part of periodontal diagnostics in addition to the indispensable clinical exploration. The focus is the measurement of available bone mass prior to, during, and after treatment, as well as monitoring following the regenerative treatment of vertical periodontal defects and furcation involvement, for example.

_Limitations of CBCT_

**Artefacts**

A major problem with all cross-sectional imaging methods is the generation of image artefacts. Typically, high-density structural elements in the object investigated (e.g., metallic restorations, root pins, implants, osteosynthesis plates) lead to obliterating and hardening artefacts in beam direction. Under certain circumstances, these may impair the diagnostic assessment of directly adjacent structures (e.g., approximal spaces, peri-implant region), and may in part even mimic pathological structures.

**Effective radiation dose**

The radiation dose for patients undergoing dental CBCT largely depends on the CBCT system, the type of detector used, and the exposition parameters of the X-ray itself. As a rule, image-intensifier systems produce a slightly lower dose than flat-panel detector systems do. The effective dose, in terms of risk management, can be reduced considerably by selecting an image volume adjusted to the area of exploration. Scientific studies have shown that the dose of CBCT may well be similar to the magnitude of intra-oral film status for a single tooth (with up to 14 individual images) and that CBCT may offer considerably higher information content in direct comparison. Nonetheless, strict indications according to the ALARA (as low as reasonably achievable) principle should be adhered to under all circumstances when employing CBCT to minimise the exploration risk for the patient.

**Imaging accuracy and precision**

When defining the precision and measuring accuracy for periodontal diagnostics, a certain degree of deviation between the clinical situation and the resulting radiological information is inevitable but can be regarded as
Regarding the reliability of radiological measurements, initial study results showed an overall measuring imprecision of two to three times the voxel size, regardless of the prior knowledge of dental radiology of the users involved. Depending on the number of roots, measuring accuracies of between 0.26 and 0.34 mm have been recorded for single-rooted teeth, and between 0.27 and 0.55 mm for multiple-rooted teeth. The effect of the individual user did not prove to be significant. In principle, these values permit the conclusion that a basic accuracy at this level, compared with measuring imprecision during clinical diagnosis of the patient, can well be considered consistent and regarded as being acceptable from a clinical point of view.

**Conclusion**

Especially for complex issues, the use of CBCT can be viewed as a valuable diagnostic tool in modern periodontology applying the ALARA principle. The undistorted and non-overlapping 3-D imaging of the tooth-supporting alveolar ridge by methods such as CBCT has significant potential in periodontal diagnostics—under the precondition of robust scientific evidence. In this context, the coPeriodontiX software described in this article is the first to offer support to users in the detection of dental, periodontal, and osseous deterioration, particularly in highly complex cases, and coPeriodontiX may be an interesting option for surgical restoration (Straumann Endopin, BioCeramic, MembranGel). Finally, it should be mentioned explicitly that the software described in this article does not replace clinical diagnosis, but should rather be viewed as a useful radiological means of support. This includes the option of portraying the soft tissue of the intra-oral gingival profile using surface scan data obtained with iTero for example (Align Technology; Fig. 5). A number of further clinical studies are being conducted using numerous diagnostic parameters to examine the technical features of current CBCT systems (e.g., image resolution, image quality, creation of artefacts) and to exploit the diagnostic potential of CBCT fully, especially for its use in periodontal diagnostics.

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**Editorial note:** A complete list of references is available from the publisher.