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Straumann® coPeriodontiX™: three-dimensional digital bone measurement using cross-sectional DVT image data in parodontological issues

With coPeriodontiX™, Straumann launches a software for the first time for the three-dimensional evaluation of parodontal bone status using cross-sectional image data (DVT). Focal point is the measurement of bone progression prior to, during and after treatment, as well as monitoring to measure the effectiveness of regenerative measures.

X-ray images have always proven a valuable tool in parodontological diagnostics [1, 2]. Usually two-dimensional imaging processes, such as bitewing images, intraoral images of single teeth or panoramic tomography are used for these purposes. All these processes are able to provide important diagnostic pointers, but none of them are without fundamental limitations [3], even at high quality images.

It is against this background that digital volume tomography (DVT) has gained increasing importance over the past few years and is now firmly entrenched in certain areas of modern dentistry [4, 5]. In today’s parodontology, DVT allows for precise answers to a number of diagnostic issues relating to structural bone changes in the dento-alveolar area [12]. High-resolution and overlap-free imaging of teeth and bone structures as well as their pathological deterioration play a major role here [6, 8, 9, 10].

The principle of radiological bone measurement

As no satisfactory software-based solutions existed to date for standardized use in the parodontological evaluation of cross-sectional data (DVT, CT), a software implementation was developed in cooperation 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 standardized evaluation follows the X-ray 6-point measuring principle in analogy to clinical assessment. By positioning a digital 3D coordinate system, placed centrally on the tooth to be measured, the software automatically generates transversal cross sections of the tooth (Figs. 1a, b).

Using settable, defined landmarks, the distance along the axis of the tooth is measured automatically at 6 measuring
points circumferentially around the tooth (vestibular and oral, with mesial, central and distal measurement in each case) to give a 360° evaluation of crestal bone status. The enamel dentin junction and crestal alveolar bone serve as reference landmarks (Figs. 2a, b). In the case of multiple-rooted teeth any possible pathological furca involvement can be clearly evaluated using a special 360° panorama view as well as metrically measuring the degree of furca involvement (Fig. 3). All findings can be provided individually in graphic or table format, as desired (Figs. 4a, b).

**Imaging processes in dentistry: 2D versus 3D**

The main disadvantage of conventional 2D image processing is the two-dimensional display of three-dimensional anatomical structures. Important morphological aspects as well as their pathological changes to the tooth-supporting alveolar ridge can only be detected at advanced stages of deterioration, or even not at all, due to overlapping images. The amount of bone available can only be determined with a certain degree of accuracy in the approximal spaces, the detection as well as quantitative determination of double- to triple-walled bone defects often remains a diagnostic challenge, even in case of high quality X-ray images [7]. In this context, coPeriodontiX™ is intended to provide the clinical user with a valuable tool and allows precise and standardized evaluation of three-dimensional cross-sectional images as part of periodontal diagnosis in addition to the indispensable clinical exploration.

The central focus is on the measurement of available bone mass prior to, during or after treatment, as well as monitoring following the treatment of vertical periodontal defects and furca involvement, for example, by regenerative measures.

**LIMITATIONS OF DVT**

» **Artifacts**

A major problem with all cross-sectional imaging methods remains the generation of image artifacts. Typically, high-
density structural elements in the investigated object (i.e. metallic restorations, root pins, implants, osteosynthesis plates) lead to obliterating and hardening artefacts in beam direction. [13] Under circumstances these may impair the diagnostic assessment of directly adjacent structures (i.e. approximal spaces, peri-implant region), and may in part even mimick pathological structures.

» Effective radiation dose
The radiation dose for patients undergoing dental digital volume tomography largely depends on the DVT system, the type of detector used, as well as the exposition parameters of the X-ray itself. As a rule, “image intensifier systems” produce a slightly lower dose than “flat panel detector systems” [11].

Here the effective dose—in terms of risk management—can be reduced considerably by selecting an image volume adjusted to the area of exploration [14]. Scientific studies have shown that the dose [15–18] of digital volume tomography may well resemble the magnitude of intra-oral film status for a single tooth (with up to 14 individual images) and at the same time offer a considerably higher information content in direct comparison [6].

Nonetheless, strict indications according to the ALARA (as low as reasonably achievable) principle should be adhered to under all circumstances when employing DVT to minimize the exploration risk for the patient.
» Imaging accuracy and precision

When defining the precision and measuring accuracy for parodontological issues, a certain degree of deviation between the clinical situation and the resulting radiological information is inevitable but can be regarded as being clinically acceptable [6, 19, 21].

Regarding the reliability of radiological measurements initial study results [22] showed an overall measuring imprecision of two to three times the voxel size, regardless of previous knowledge in dental radiology of the users involved. Depending on the number of roots, measuring accuracies of between 0.26 to 0.34 mm recorded for single-root teeth, and between 0.27 to 0.55 mm for multiple-root teeth.

The effect of the individual user component did not prove to be significant. In principle, these values permit the conclusion that a basic accuracy at this level, compared to 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 DVT can be viewed as a valuable diagnostic tool in modern parodontology applying the ALARA principle. The un-
distorted and non-overlapping three-dimensional imaging of the tooth-supporting alveolar ridge by methods such as DVT has the potential of playing a major role in parodontological diagnostics – under the precondition of robust scientific evidence. In this context, the coPeriodontiX software described here offers a first opportunity for supporting users in the detection of dental, parodontal as well as ossary deterioration. In specific this includes highly complex cases, and coPeriodontiX™ may also be an interesting option for surgical restoration (Straumann® Emdogain, BoneCeramic, Membragel).

Finally it should be mentioned explicitly that the software described here does under no circumstances replace clinical diagnosis, but should rather be viewed as a useful radiological means of support. Last but not least, this includes the option of portraying the soft tissue of the intraoral gingiva profile using Surface Scan data, for example, iTero™ (Fig. 5).

Perspectively, a number of further clinical studies are currently being conducted taking into account numerous diagnostic parameters to examine the technical features of presently marketed DVT systems (i.e. image resolution, image quality, creation of artifacts) and to exploit the existing diagnostic potential of DVT fully in the future, especially for its use in parodontological issues.