Micro computed tomography for the investigation of tooth hard tissues

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INTRODUCTION: Absorption-based X-ray micro computed tomography is a well-established technique for the investigation of human crown's density.[1-3] The reconstructed tomograms yield the local X-ray attenuation coefficients μ. Since μ depends on the X-ray energy as well as linearly on the material density, measurements performed with monochromatic X rays, as performed at synchrotron radiation facilities, provide quantitative results about tissue density. Conversely, the attenuation coefficients obtained with a polychromatic X-ray spectrum, as found e.g. in advanced laboratory sources, are only of semi-quantitative nature. It is, therefore, of significant interest to correlate the results from the two facilities.

METHODS: The crown of a human tooth, extracted for reasons unrelated to the study, was used for the investigation. Lab-source micro computed tomography was performed with a nanotom® m (General Electric, Wunstorf, Germany) with an acceleration voltage of 90 kV. The pixel size of the 1200 equiangular projections corresponded to 4.8 µm. Synchrotron radiation-based tomograms were acquired at the beamline P07 operated by HZG at PETRA III (DESY, Hamburg, Germany) with a photon energy of 45 keV and a pixel size of 4.8 µm. 2400 equiangular projections were acquired over 180°.

RESULTS: The images in Figure 1 display a selected slice from the datasets obtained with monochromatic and polychromatic X rays, respectively. Dentin and enamel as well as the lesions can clearly be identified in both datasets. Figure 2 shows the joint histogram of the two datasets. Here, the grey values obtained by the nanotom setup are compared with the local X-ray absorption values obtained with monochromatic radiation. The attenuation values scale almost linearly, indicating that the data acquired with the chosen settings for the laboratory source reasonably reflect the density of the tooth crown.

DISCUSSION & CONCLUSIONS: Quantitative synchrotron X-ray tomography allows for the calibration of the grey values obtained with lab-sources.

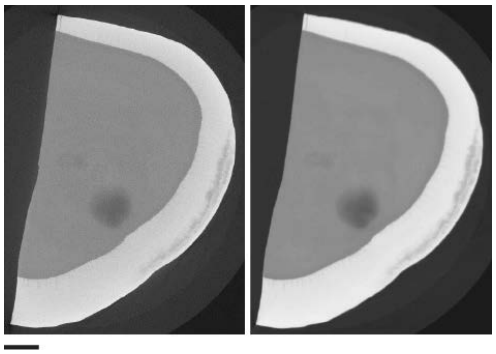

Fig. 1: Selected slices from laboratory- (left) and synchrotron radiation-based (right) CT data. The length bar corresponds to 1 mm.

The beam time at synchrotron radiation sources is limited. Our approach enables us to derive local densities from data of laboratory-based systems for the quantification of tooth hard tissues in health and disease.

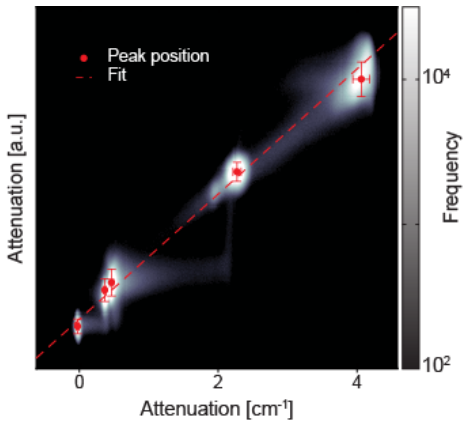

Fig. 2: Joint histograms of the two datasets. Abscissa – SR data, ordinate – nanotom data.

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