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Optimization of Clinical CT by Means of Micro Computed Tomography

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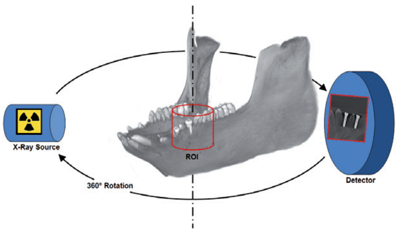
INTRODUCTION

Metal implant supported restorations in dentistry have been widely accepted to treat patients who need a tooth root replacement. Cone beam computed tomography (CBCT) is an effective tool for pre-operative planning and implant selection. The cross-sectional images allow selecting the appropriate implant length and diameter as well as the desired implant position. CBCT can not likewise be utilized for post-operative imaging because huge artifacts appear as bands and streaks around the metal implant. In order to understand the related phenomena and finally to reduce the artifacts, CBCT scans of a pig jaw and a human cadaver head with two conventional implants were performed varying the acceleration voltage, the beam current and the position of jaw and head with respect to source and detector

CBCT

For the pig jaw investigation, two titanium implants (Straumann AG, Villeret, Switzerland) each 4.1 mm in diameter and 10 mm in length were inserted into the pig jaw. The dental CBCT 3D Accuitomo 60 (Accuitomo, Morita, Japan) provided the volumetric data.
The data acquisition implies the 360° rotation of X-ray source and detector around the specimen within about 18 s. Besides tilting the jaw in a frontal and sagital plane in steps of about 5 degrees (α, β) we also varied the accelerating voltage from 70 kV to 80 kV and cathode current from 1 mA to 10 mA.



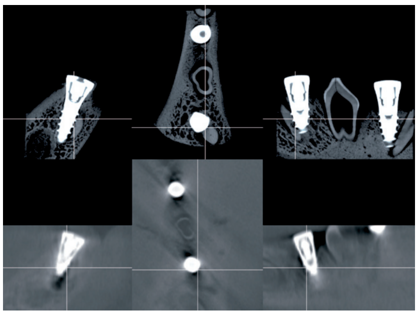
Subsequently, a plastified cadaver head with two titanium screw implants was used for CBCT measurements to characterize the influence on image quality of implant tilting with respecto to detector and source.
The head was measured at 10, 20, 30, 40 and 45 degree angles in the sagittal (α), and frontal (β) plane.

ARTIFACT REDUCTION

The head of the patient is oriented that teeth, potential implants, X-ray source and detection-unit are arranged in a single plane. This is the worst case, since highly X-ray absorbing components in line causes the strongest artifacts. We hypothesize that tilting the patient's head will reduce artifacts. The effect should be clear for patients with multiple implants, because the tilting can prevent the overlapping of the strongly X-ray absorbing materials.

REGISTRATION

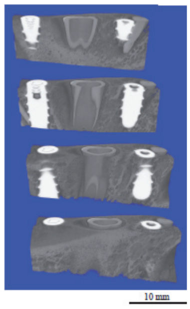
For comparison, the tomography data of the pig jaw were cropped to the common volume. For this purpose, the data were manually pre-registered. Pre-registration ensures a reasonable estimate for the automatic registration procedure



The three images in the top row are slices perpendicular to each other obtained from the microCT scan, whereas the slices below are dental CBCT data

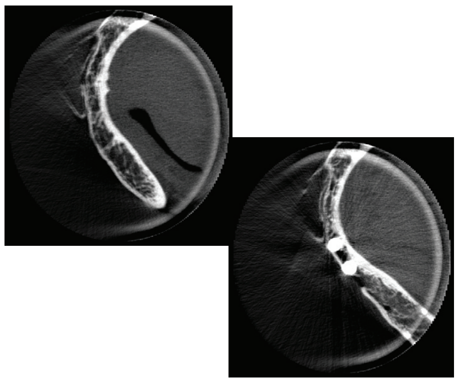
SRµCT

SRµCT data of the implants in the pig jaw were acquired at the beamline W2 (HASYLAB at DESY, Hamburg) using a photon energy of 76 keV. The dataset is composed of eight individual scans acquired at different positions, resulting in a volume of 1199x1199x332 voxels³ representing 32.3x32.3.8.9 mm³.



FOLLOW-UP

The datasets of the human head recorded at different angular positions will be registered against a reference scan, which simulates the conventional clinical condition, with the head in a horizontal position. Variations in image quality will be quantified by a previously defined quality factor. An algorithm to determine the optimal tilting angle of implants will be developed.



CONCLUSION AND ACKNOWLEDGEMENT

The SRµCT measurements provide the baseline that can be used to quantify artifacts generated in clinical CT. Therefore, the clinical CT data acquired at different accelerating voltages, beam currents and geometrical arrangements can be directly compared for optimization purposes. As expected, the increase in the accelerating voltage improves image quality. Preliminary results indicate that slight tilting of the patients head permits a significant reduction of artifacts. Further data evaluation is necessary to finally instruct the CBCT operator how to image the patients jaw in an optimized manner.
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