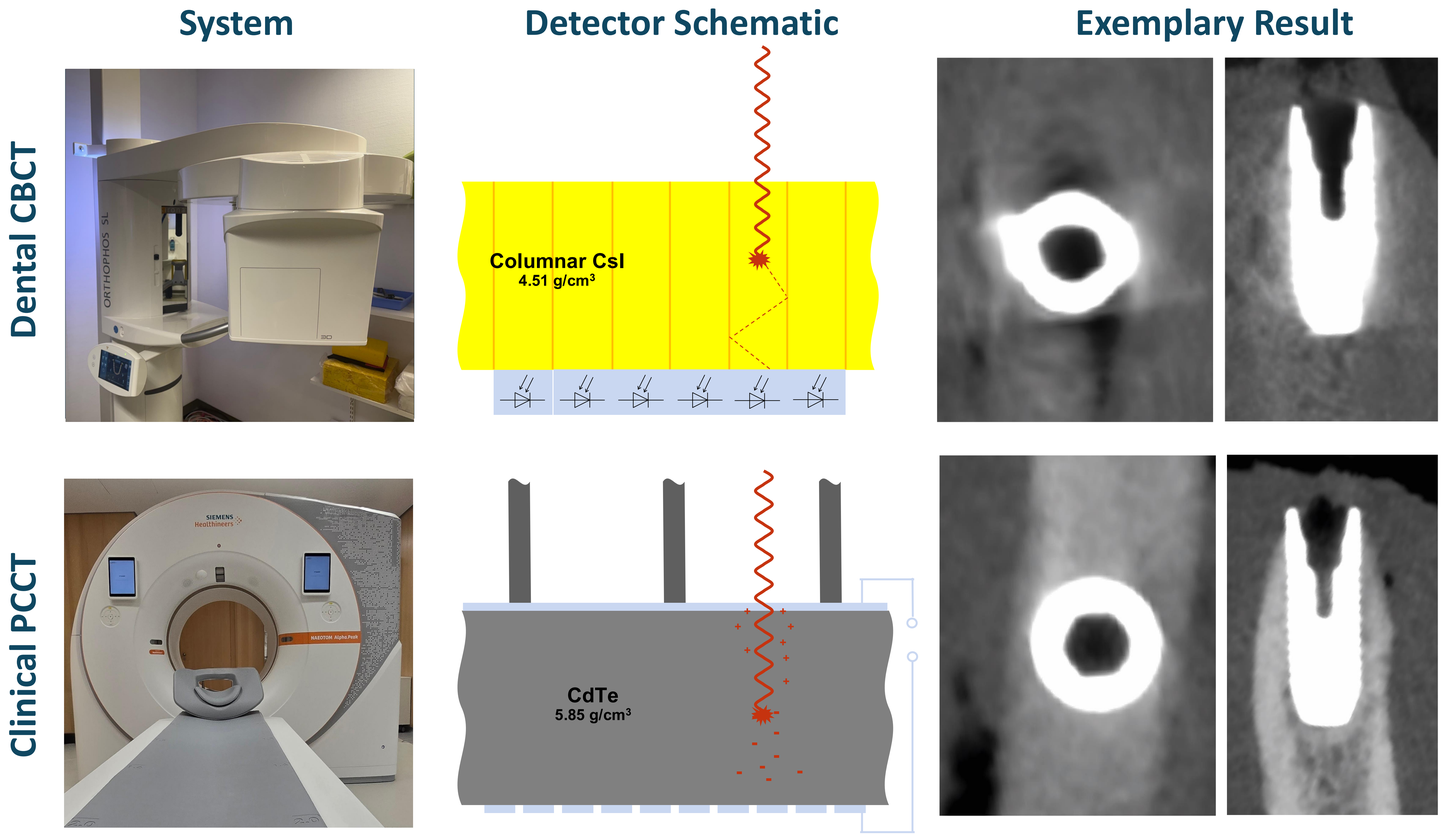
Photon-Counting Computed Tomography (PCCT) for the Visualization of Bone Defects Around Titanium Implants

C. Mertens, M.F. Froelich, S.O. Schoenberg, T.-S Kim, M. Kachelrieß, S. Sawall, and M. Ruetters

Introduction

Peri-implantitis is characterized by inflammation of the peri-implant mucosa and progressive bone loss, requiring precise clinical and radiological diagnostics. While cone-beam computed tomography (CBCT) enables three-dimensional assessment, its diagnostic accuracy is often limited by metal and motion artifacts. Clinical photon-counting computed tomography (PCCT), offering higher spatial resolution and reduced radiation dose, may overcome these limitations and provide improved visualization of peri-implant bone defects compared to conventional CBCT. The primary aim of this study is to validate clinical PCCT as an advanced imaging modality for the assessment of peri-implant bone defects, evaluating its potential as a superior alternative compared to CBCT in implantology.



Imaging modalities used in this study, schematics of the used detector technology and exemplary results. Top: Dental CBCT using a conventional energy-integrating detector that converts x-ray photons to optical photons using a CsI-based scintillator. Bottom: Clinical photon-counting CT the directly converts x-ray photons to measureable charge clouds using a semiconductor.

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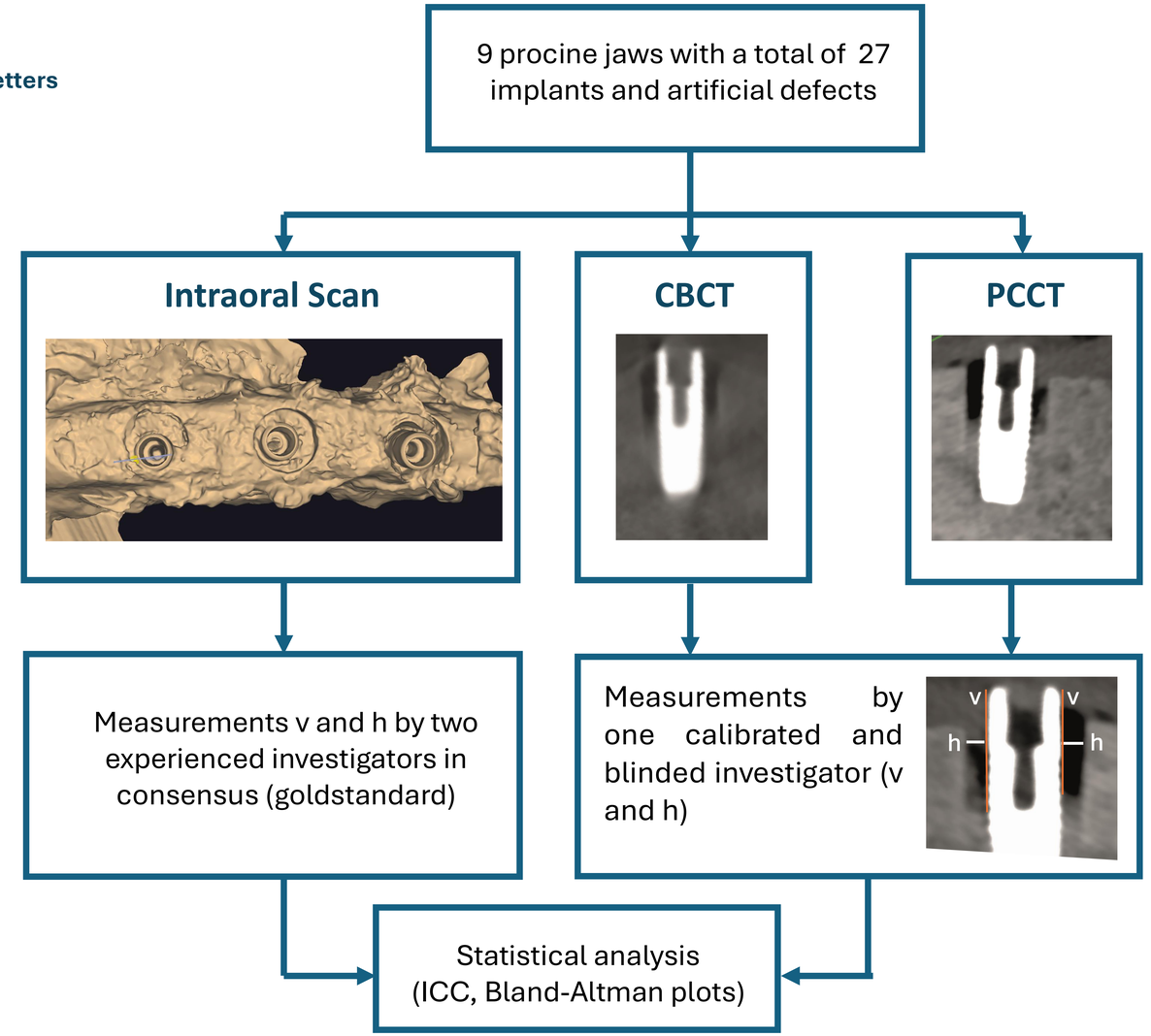
Materials and Methods

Artificial peri-implant bone defects were created in nine porcine jaws, each containing two to three titanium implants. The defects were first scanned using an intraoral scanner, followed by PCCT and CBCT. Radiation exposure was comparable between both imaging protocols. At each implant, two vertical (*v*) and two horizontal (*h*) defect component were measured by a calibrated examiner at two randomly selected sites. Measurements from the intraoral scans served as the goldstandard. Intraclass correlation coefficients (ICC) and Bland-Altman plots were used to assess agreement between PCCT or CBCT measurements to the gold standard.



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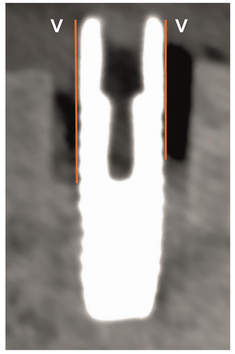
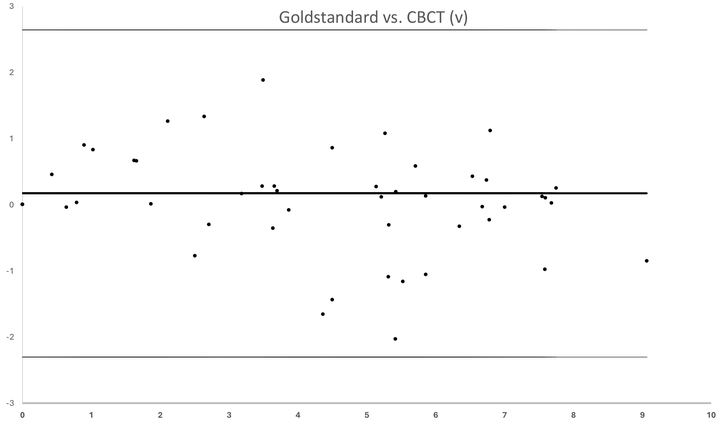
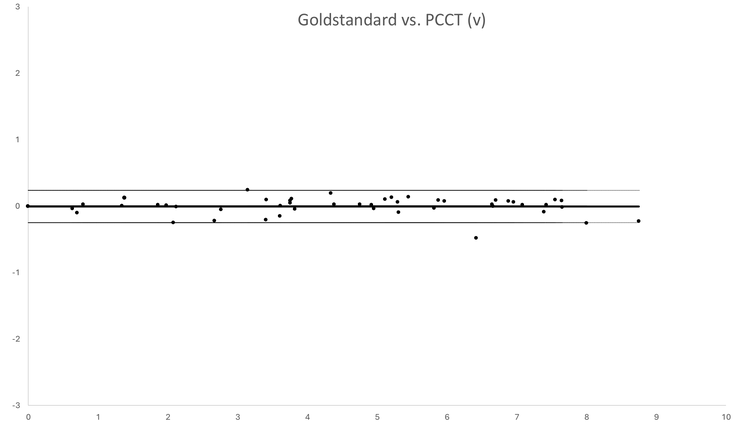
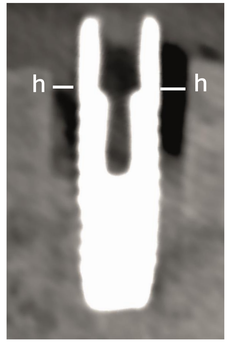
Results

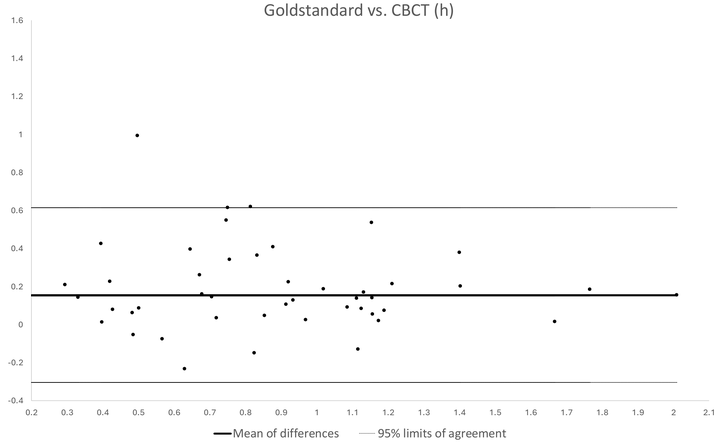
ICC values for agreement with the gold standard were **0.998** for vertical and **0.959** for horizontal defects in PCCT, and **0.940** for vertical and **0.799** for horizontal defects in CBCT. Bland–Altman analysis likewise demonstrated superior agreement and smaller 95% limits of agreements of PCCT compared to CBCT for *h* and *v*.

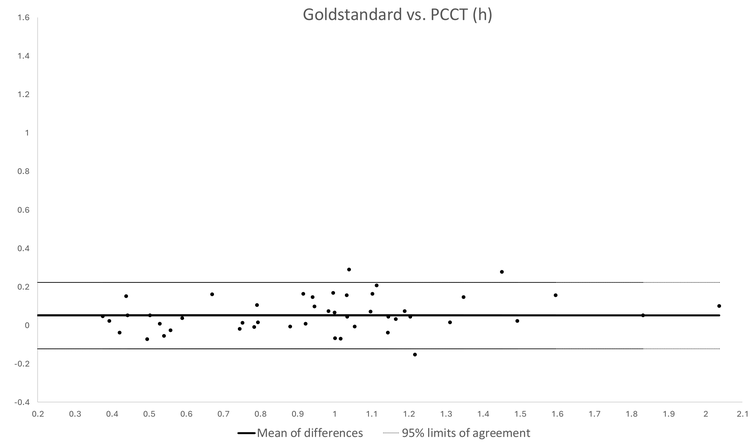












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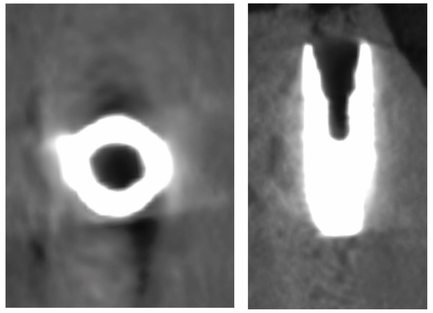
Conclusion

The results indicate that **PCCT provides more accurate visualization of peri-implant bone defects compared to conventional CBCT**. This improvement can be attributed to substantially reduced artifacts and image noise in PCCT, allowing clearer and more precise delineation of bone structures adjacent to metallic implants. In the future, PCCT could significantly enhance diagnostic imaging in dental implantology.

Conventional CBCT Detector



Photon-Counting Detector