# Coherent Synchrotron-Based Micro-Imaging Employed for Quantitative Studies of Micro-Gap Formation in Dental Implants

T. Rack[1], S. Zabler[2], A. Rack[3], M. Stiller[1], H. Riesemeier[4], K. Nelson[1]

[1]*Charité, Campus Virchow Clinic, D-13353 Berlin, Germany*
[2]*Technical University, Straße des 17. Juni 135, D-10623 Berlin, Germany*
[3]*European Synchrotron Radiation Facility, BP220, F-38043 Grenoble, France*
[4]*Bundesanstalt für Materialforschung und –prüfung, D-12200 Berlin, Germany*

**Abstract:**
The success rate of dental implants is often reported as "of the order 100%". Yet, this number only states that no revision was necessary within the first 5 years after implantation. On the long term a variety of failure scenarios are known which can cause a revision and / or implant loosening. Due to production limitations for these small devices, the joint between implant and abutment is characterized by a small micro-gap. Design, micro-gap and geometrical tolerances have a tremendous impact on the fatigue lifetime and on the cyclic deformation of dental implants under non-axial load.

Therefore, we investigated micro-gap formation at the implant-abutment interface of two-piece dental titanium implants *in vitro* under different mechanical loads. The aim of this study was to display the occurrence of micro-gaps for different two-piece dental implant designs with conical connections. Furthermore, the micro-gaps under different loads were studied in a quantitative manner, allowing for a correlation with, e.g., leak-proof tightness [1].

Experiments were carried out using high resolution radiography in combination with hard X-ray synchrotron radiation. Synchrotron-based radiography yields high spatial resolution together with high contrast even when exploiting micro-sized features in highly attenuating objects. Due to the coherence of the synchrotron light, even structures below the resolution limit of the imaging system can be detected by means of X-ray phase contrast. Adapted numerical routines are used to retrieve the real spatial dimensions of those features [2].

Several sets of radiographic projection images were acquired at the BAM*line* (BESSY-II light source, Helmholtz Zentrum Berlin, Germany). A micro-gap was detectable for all four different design systems under study. Its size naturally depends on the force as well as the angle under which the load is applied [3].

The existing designs for two-piece dental implants need to be enhanced in order to guarantee leak-proof tightness and therefore avoid microbial colonization of the internal cavity of the implant–abutment complex. Hence, there is room to further increase the success for two-piece dental implants [4].

**References:**

[1] A. Rack, T. Rack, M. Stiller et al., J. Synchrotron Radiat. **17**, 289 (2010).
[2] S. Zabler, H. Riesemeier, P. Fratzl et al., Opt. Express **14**, 8584 (2006); http://www.opticsexpress.org/abstract.cfm?URI=oe-14-19-8584.
[3] A. Rack, S. Zabler, B.R. Müller et al., Nucl. Instrum. Methods A **586**, 327 (2008).
[4] W. Semper, S. Kraft, T. Krüger et al., J. Dent. Res. **88**, 725 (2009).