Measuring system for synchrotron CT to characterize nanoparticles release on human organoids exposed to metal implant

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Abstract

The effects of an implant's surface structure on clinical complications, such as infection or lack of osseointegration, are still not conclusively investigated. In particular, the role of nanoparticles or microparticles migrating from implants into the surrounding tissue is the subject of current research and development as well as new regulations concerning its risk assessment. Local exposure can lead to increased local inflammation or hypersensitivity reactions (Figure 1). These may be accompanied by inflammatory response of the surrounding tissue and loss of quality of the peri-implant bone (osteolysis), resulting in premature failure of the implant. The size and crystal structure of the released particles determine the nature of the foreign body reaction and thus the impact of the particular biological effect. Ex vivo studies or animal models provide only an inadequate risk assessment for the use of implants in humans, since they cannot fully simulate either the mechanical requirements or the chemical environment.

A new field of toxicity testing is represented by in vitro cultures using human organoids in microfluidic systems, so called organ-on-a-chip. Three dimensional (3D) cultures are designed to represent the function of the respective target organ and are based on multicellular approaches. In vitro analysis provides essential information about the interaction of human cells with the surface for cell proliferation. The combination of this novel in vitro analysis with Synchrotron CT (computer tomography) enables measuring the release of nanoparticles from the implant to the organoid. Synchrotron radiation enables superior spatial resolution than conventional CT scanners and its radiation intensity I with high signal-to-noise ratio on short time-scales results in high contrast images. This paper presents the development of a measurement system that enables tracking the release of metal nanoparticles on human cells over time. This method represents a pioneering technology for in vitro analysis.