Multi-modal correlative microscopy of mineralization in relation to human dental caries

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Abstract

Dental caries (tooth decay) is a major public health problem that continues to affect people of all ages globally, with the World Health Organization estimating that 2.3 billion people (32% worldwide) have dental caries in their permanent teeth. This continued demand for dental treatment and prevention has led to the greater need for an understanding the micro and nano structure of human teeth. Dental caries begins at the outermost layer of teeth (enamel), which is a highly mineralized substance that covers the crown portion of the teeth and serves as the wear-resistant part of teeth. On the microscopic scale enamel consists of keyhole shaped rods (approximately 5 um width) aligned approximately perpendicular from the dentin crown outwards to the surface. These rods are primarily composed of inorganic biological hydroxyapatite crystals (approximately 25–30 nm of thickness), which are covered by a nanometre-thin layer of enamel in and oriented along the rod axis.

The progression of dental caries is associated with demineralisation and occurs due to the depletion of mineral ions from the hydroxyapatite crystallites due to organic acids produced from bacteria on the surface of enamel. In accordance with the structural organisation of hydroxyapatite, enamel demineralisation may take place in different ways depending on crystallite orientation. Of a particular interest is Type I demineralisation, when dissolution occurs mainly in the rods core, whilst the interfacial area between rods (inter-rod enamel) is somewhat preserved. We report a range of approaches to 2D mapping and 3D tomographic visualization of pristine (healthy) and carious (demineralized) enamel and dentine using different imaging modalities based on optical microscopy, as well as the use of X-ray, electron and ion beams. We seek to establish correlation between structural elements and features present at different scales, with a view to obtaining new insights into the progression and evolution of caries and the various structures that emerge in the process of demineralization a remineralization.

Biography:

Alexander M. Korsunsky is a world-leader in engineering microscopy of materials systems and structures for optimization of design, durability and performance. He leads MBLEM lab at the University of Oxford, and the Centre for In situ Processing Science (CIPS) at Research Complex at Harwell. He consults Rolls-Royce plc on matters of residual stress and structural integrity, and is Editor-in-Chief of Materials & Design, a major Elsevier journal (2018 impact factor 4.252). AMK leads a major EPSRC research project on nanoscale analysis and modelling of human dental caries.

Citation: Alexander M. Korsunsky; Multi-modal correlative microscopy of mineralization in relation to human dental caries; Dental Webinar 2021; March 25, 2021