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Deformation Behavior and Biomechanical Properties of Enamel and Dentine about a White Spot Lesion

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Statement of the Problem: The appearance of acids in the oral cavity may occur during the consumption of a number of foods and beverages, and also as a result of the vital activity of cariogenic bacteria, which contributes to the demineralization process - partial dissolution of the main structural elements of enamel - hydroxyapatite crystallites. Early caries is characterized by the process of demineralization of tooth enamel without cavitation under a relatively intact tissue surface. In this case, pores appear in the subsurface region. Due to the significant difference in the refractive indices of the medium within the porous area and the sound tissues surrounding it, a whitish opaque region appearance of demineralized pathologically altered enamel lesions can be observed. This phenomenon is called white spot lesion (WSL). Overall, the number of studies characterizing the fundamental changes that emerge in natural WSLs from materials, microstructural and biomechanical point of view remains rather low. Methodology & Theoretical Orientation: The present work aims to characterize the complex of properties (mineral density, reduced Young's modulus, indentation hardness, average roughness, maximum height of roughness) and features (surface structure, molecular composition, indentation creep) of the enamel and dentine about a WSL on a single tooth using computed X-ray microtomography, bitewing X-ray, nanoindentation, Raman spectroscopy, scanning electron (Figure 1), atomic force and optical microscopy. The aim of obtaining such information is to provide the basis for future studies of efficacy of minimal invasive treatments of caries and deeper analysis of these properties and features. Conclusion & Significance: The work reveals some fundamental changes emerging inside human enamel and dentine at the first clinically visible stage of the carious disease from several points of view. The complex of characteristics was found for the natural enamel WSL and dentine bordering it. The properties obtained were compared to those of sound counterparts of the aforementioned areas on the same tooth. The significant reduction of the mechanical properties was recorded for both carious areas accompanied by the abnormality of the unloading response and change of the character of indentation marks caused by mineral loss. Increase of indentation creep for WSL area was recorded. The maps of mechanical properties show that the enamel outside the WSL is weakened despite its appearance as being sound on optical and bitewing X-ray images. At the same time, the decrease in mineral density of the WSL area and bordering dentine was rather small. The average roughness of polished surfaces was considerably increased in the caries-affected areas caused by the demineralization process, and the surface relief changed as well. Raman spectroscopy research resulted in detection of interesting repeatable features connected to changes in the molecular composition in the carious areas. This research was funded by the Russian Science Foundation, grant number 19-19-00444.

Biography

Evgenii Sadyrin, M.S., Junior Researcher of the Laboratory for Mechanics of Biomaterials, Don State Technical University. The main research interests of Mr. Sadyrin include biomechanics of tooth tissues, nanoindentation, microtomography, atomic force microscopy, scanning electron microscopy, Raman spectroscopy, biocompatible coatings, mathematical modelling. Mr. Sadyrin is currently involved in research projects on biomechanics of the tissues of oral cavity and eyeball and optimized biocompatible materials for implantation.