YENEPOYA

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Details of the Collaborative Activity

2018-2019

Name of the Collaborating Institute: Raja Ramanna Centre for Advanced Technology (RRCAT), Indore

Name of the Collaborating Department from YDU: Yenepoya Research Center

Joint Research:

The faculty and Research scholars of YDU utilized the synchrotron facilities for a joint research project at Technical Physics Division, Indus-2, Raja Ramana Centre for Advanced Technology (RRCAT), BARC, Indore.

1. Mr. Jagadish Kudkuli,
2. Dr. Rekha PD,
3. Mr. Muhammad Manzoor AP
4. Dr. Riaz Abdulla

Joint Research Publications

1. Jagadish K, Ashish A, Om PG, Sunil DS, Rekha PD, Manzoor MAP, Singh B, Rao BS, Abdulla R. Demineralization of tooth enamel following radiation therapy; An in vitro microstructure and microhardness analysis" Cancer Research and Therapeutics, 2021. DOI: 10.4103/jcrt.JCRT_8_19
2. **Jagadish K, Abdulla R, Rekha PD**, Sharma SD, Gurjar OM, "Spectroscopic analyses reveal radiotherapy-induced variations in elemental composition and crystallite properties of human permanent teeth enamel, *Journal of Biosciences*, 2019. DOI: https://doi.org/10.1016/j.job.2019.10.002
3. **Manzoor MAP**, Ashish KA, Balwant S, **Mujeeburahiman M, Rekha PD**, Morphological characteristics and microstructure of kidney stones using synchrotron radiation µCT reveal themechanism of crystal growth and aggregation in mixed stones, *PLOS ONE*, 2019, https://doi.org/10.1371/journal.pone.0214003.
4. **Manzoor MAP**, Singh B, Agrawal AK, **Arun AB, Mujeeburahiman M, Rekha PD**. Morphological and micro-tomographic study on evolution of struvite in synthetic urine infected with bacteria and investigation of its pathological biomineralization. PLoS ONE. 2018; 13(8):e0202306.doi:10.1371/journal.pone.0202306

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RESEARCH ARTICLE

Morphological characteristics and microstructure of kidney stones using synchrotron radiation μCT reveal the mechanism of crystal growth and aggregation in mixed stones

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Abstract

Understanding the mechanisms of kidney stone formation, development patterns and associated pathological features are gaining importance due to an increase in the prevalence of the disease and diversity in the presentation of the stone composition. Based on the microstructural characteristics of kidney stones, it may be possible to explain the differences in the pathogenesis of pure and mixed types of stones. In this study, the microstructure and distribution of mineral components of kidney stones of different mineralogy (pure and mixed types) were analyzed. The intact stones removed from patients were investigated using synchrotron radiation X-ray computed microtomography (SR-μCT) and the tomography slice images were reconstructed representing the density and structure distribution at various elevation planes. Infrared (IR) spectroscopes, X-ray diffraction (XRD) and scanning electron microscopy (SEM) were used to confirm the bulk mineral composition in the thin section stones. Observations revealed differences in the micro-morphology of the kidney stones with similar composition in the internal 3-D structure. Calcium oxalate monohydrate stones showed well-organised layering patterns, while uric acid stones showed lower absorption signals with homogenous inner structure. Distinct mineral phases in the mixed types were identified based on the differential absorption rates. The 3-D quantitative analysis of internal porosity and spatial variation between nine different types of stones were compared. The diversity among the microstructure of similar and different types of stones shows that the stone formation is complex and may be governed by both physiological and micro-environmental factors. These factors may predispose a few towards crystal aggregation and stone growth, while, in others the crystals may not establish stable attachment and/or growth.

Original Article

Demineralization of tooth enamel following radiation therapy; An *in vitro* microstructure and microhardness analysis

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ABSTRACT

Objective: The objective of this study is to evaluate the effects of radiotherapy doses on mineral density and percentage mineral volume of human permanent tooth enamel.

Materials and Methods: Synchrotron radiation Xray microcomputed tomography (SRμCT) and microhardness testing were carried out on 8 and 20 tooth samples, respectively. Enamel mineral density was derived from SRμCT technique using ImageJ software. Microhardness samples were subjected to Vickers indentations followed by calculation of microhardness and percentage mineral volume values using respective mathematical measures. Data were analyzed using paired *t*-test at a significance level of 5%. Qualitative analysis of the enamel microstructure was done with two-dimensional projection images and scanned electron micrographs using μCT and field emission scanning electron microscopy, respectively.

Results: Vickers microhardness and SRμCT techniques showed a decrease in microhardness and an increase in mineral density, respectively, in postirradiated samples. These changes were related to mineral density variation and alteration of hydroxyapatite crystal lattice in enamel surface. Enamel microstructure showed key features such as microporosities and loss of smooth homogeneous surface. These indicate tribological loss and delamination of enamel which might lead to radiation caries.

Conclusions: Tooth surface loss might be a major contributing factor for radiation caries in head-and-neck cancer patients prescribed to radiotherapy. Such direct effects of radiotherapy cause enamel abrasion, delamination, and damage to the dentinoenamel junction. Suitable measures should, therefore, be worked out to protect nontarget oral tissues such as teeth while delivering effective dosages to target regions.

KEYWORDS: Head-and-neck cancer, microhardness, radiotherapy, SRμCT, tooth enamel

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INTRODUCTION

Oral squamous cell carcinoma is the sixth most common cancer reported globally, with an annual incidence of over 3,000,000 cases of which 62% arise in developing countries.[1] Vital head-and-neck (H and N) anatomy and severe metastasis of affected squamous epithelial tissues are serious challenges for successful implementation of radiation which is a principal mode of H and N cancer treatment to improve the tumor control probability of target areas. However, the focus has become increasingly prominent to reduce normal tissue complication probability that is likely to occur on normal tissues surrounding the target. This has led to rapid advancements in technology and delivery methods of radiotherapy which has opened up preferences between ^{60}Co gamma-rays and high-energy X-rays (typically 6 megavoltage [MV] X-rays from medical electron linear accelerators [LINACs]) among various other upgraded systems. Notwithstanding such developments, the severity of oral sequelae continues to persist, affecting quality of life (QOL) of H and N cancer patients. The high ionization potential of MV radiation and maximum fractions of radiation dose administered to oral tumor cells are the major factors for indirect side effects induced upon salivary gland damage such as mucositis, xerostomia, taste loss, trismus, and direct side effects such as progressive loss of periodontal ligament, osteoradionecrosis, and radiation caries.[2]

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PLOS ONE

RESEARCH ARTICLE

Morphological and micro-tomographic study on evolution of struvite in synthetic urine infected with bacteria and investigation of its pathological biomineralization

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Competing interests: The authors have declared that no competing interests exist.

Abstract

Pathological biomineralization in the urinary system leads to urolithiasis. Formation of kidney stones involves a series of events during which they undergo morphological and mineralogical changes. We investigated the mineralization of biogenic struvite (*in vitro*) and examined the transformation of distinct interior and exterior structure of struvite. *In vitro* crystallization of struvite was performed in the presence of two bacteria that were originally isolated from the kidney stone patients. Morphological evaluation was carried out using SR-μCT as well as FESEM, XRD and FT-IR. Characteristic internal 3-D morphology and porosity of the stones were studied. For comparison, patient derived struvite stones were used. From the results obtained, we report that the presence of bacteria enhances the crystallization process of struvite *in vitro*. A series of time-resolved experiments revealed that struvite crystals experienced a significant morphologic evolution from pin pointed structure to X-shaped and tabular morphologies. These X-shaped and unusual tabular habits of struvite resembled biogenic morphologies of struvite. SR-μCT showed similarities between the patient derived and the *in vitro* derived struvite crystals. In conclusion, these experiments revealed that the bacteria play a major role in the specific morphogenesis of struvite and can able to control the nucleation, modulate crystalline phases, and shape of the growing crystal.

Introduction

Urolithiasis (kidney stones) developed as a result of urinary tract infections makes up approximately 10–15% of all stones worldwide [1]. Struvite is the most frequent type of infection stone with mineral composition of magnesium ammonium phosphate hexahydrate ($MgNH_4PO_4{\cdot}6H_2O$). It is associated with infection caused by urease-producing microorganisms [2–4]. Breakdown of urea of urine by bacterial urease into carbon dioxide and ammonia leads to alkaline pH and elevates

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Original Article

Spectroscopic analyses reveal radiotherapy-induced variations in elemental composition and crystallite properties of human permanent teeth enamel

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Highlights

- *In vitro* radiation exposure can directly affect non target tissues, such as teeth.