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ORIGINAL PAPER

Investigation of the microstructure and mineralogical composition of urinary calculi fragments by synchrotron radiation X-ray microtomography: a feasibility study

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Abstract The outcomes from the feasibility study on utilization of synchrotron radiation X-ray microtomography (SR-μCT) to investigate the texture and the quantitative mineralogical composition of selected calcium oxalate-based urinary calculi fragments are presented. The comparison of the results obtained by SR-μCT analysis with those derived from current standard analytical approaches is provided. SR-μCT is proved as a potential effective technique for determination of texture, 3D microstructure, and composition of kidney stones.

Keywords Computed microtomography · Synchrotron radiation · Urinary calculi · Texture · Microstructure

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Introduction

Among all types of urinary calculi that are affecting the populations of industrialized countries, the frequency of calcium stone is 70–80% [1]. The primary component of 70–80% of calcium stones in the US is the calcium oxalate [2, 3].

The susceptibility of the calcium oxalate stones to the shock wave (SW) lithotripsy [4], which is one of the methods of nephrolithiasis therapy, is varying dramatically depending on their fragility. Some homogenous and compact calculi being very resistant, and others, with heterogeneous and less compact structure are quite fragile [5]. Modeling and optimization of SW lithotripsy need the knowledge of treated stones mineral composition and structure [6]. The study of urolithiasis requires not only identification of constituents and minerals, but also knowledge about their internal texture and structure. Current methods of chemical analysis (AAS, ICP-OES, ICP-MS), which are based on determination of analytes after sample dissolution [7], provide only information on bulk composition of uroliths. It was already found at initial mineralogical studies of urolith thin sections by means of optical microscopy in polarized light that uroliths exhibit distinct concentric texture, which indicates dynamics of urolith evolution. Concentric texture is manifested by zonation of mineralogical composition and amorphous constituents as well as by mineral grains size and degree of perfection of their crystallographic arrangement [8]. Recent studies underlined the necessity to perform analysis of urinary calculi at the mesoscopic scale. Close relationship between the stone morphology and crystallite organization at the mesoscopic level and the effectiveness of extracorporeal SW lithotripsy was shown, e.g., in [9]. Another study [10] using SEM confirmed a crystalline structure in