Observation of phase transition of calcium oxalate in a human kidney stone for elucidation of the stone formation mechanism

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Introduction

Urinary stones are composed of crystalline phases (more than 90%) and organic components (~10%). Calcium oxalate (CaOx) is the main crystalline component of most stones, and it contains monohydrate (COM; stable phase) and dihydrate (COD; metastable phase) [1]. The inside of COD undergoes a phase transition to COM. We have previously reported that the phase transition phenomenon of calcium oxalate (CaOx) makes urinary stones harder [2]. Knowing phase transition velocity helps estimate the change of the patient's stone hardness over time. It affects the decision-making of the fragmentation treatment by the shock wave and laser. However, the mechanism of the phase transition has not been clarified. Therefore, we stimulated the phase transition of COD to COM, and observed the time course of the internal and surface structure.

Methods

A urinary stone mainly composed of COD crystals, in which the phase transition has not progressed much, was stored in a vial containing CaOx supersaturated solution at 37°C with gentle shaking. We picked up the stone from the solution every week and observed the phase transition process from COD crystals to COM crystals. X-ray micro-CT and scanning electron microscopy were introduced. After completing the phase transition observation, a thin section of the stone was prepared. Then, the phase identification was performed in more detail using polarizing microscopy and Raman microscopy.

Results

The dissolution of the COD crystal surface and nucleation of COM crystals co-occurred. The inside of the COD crystal underwent a phase transition to COM crystals. We found typical mosaic structures and concentric structures of COM crystals after the transition. The extent of the transition from COD crystals to COM crystals strongly depended on the area. In some regions, a few millimeter size COD crystals almost turned into COM crystals in 2 weeks.

Conclusion

Our observation showed experimental phase transition of a natural urinary stone is faster than that in the human body, and indicated a potential mechanism enabled to slow down the phase transition of crystals *in vivo*, which could be useful to prevent stone formation.

References

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