Topography, composition and structure of incipient Randall's plaque at the nanoscale level

Emmanuel Letavernier[1], Cécile Verrier[1], Dominique Bazin[1,2], Odile Stephan[2], Alexandre Gloter[2], Marie-Christine Verpont[1], Vincent Frochot[1], Jean-Philippe Haymann[1], Isabelle Brocheriou[1], Olivier Traxer[1], Michel Daudon[1]

1Université Pierre et Marie Curie-Paris VI Sorbonne Universités, France;
[2]Laboratoire de Physique des Solides, CNRS UMR 8502, Université Paris Sud XI, Orsay, France

Alexander Randall identified calcium phosphate plaques in renal papillae as the origin of kidney stones. However, little is known about the early steps of Randall's plaque formation, preceding the onset of urolithiasis. Our objectives were to characterize the composition and the initial formation site of incipient Randall's plaque in non-stone formers living patients. Fifty-four healthy papillae from kidneys removed for cancer have been analyzed by immunohistochemistry and Von Kossa staining, Field Emission-Scanning Electron Microscopy with Energy Dispersive X-ray analysis, l-Fourier Transform Infrared Spectroscopy, Cryo-Transmission Electron Microscopy coupled to Selected-Area Electron Diffraction and Electron Energy Loss Spectroscopy. Incipient Randall's plaque has been observed in 72.7 % of kidneys. Carbonated apatite was as expected the main component of microcalcifications but amorphous calcium phosphate and whitlockite have been identified in 80 and 40 % of the papillae, respectively. Incipient plaques stood in the deepest part of the papillae, around the loop of Henle tip but also around vasa recta (respectively 62.4 and 37.2 % of microcalcifications) and rarely close to collecting ducts. At the nanoscale level, calcifications were often made of several nanocrystals inside organic material looking like microvesicles. In conclusion, incipient Randall's plaque is frequent and appears at the tip of renal papillae, around the hairpin structure of the loop of Henle and vasa recta as well. Nanoscale analyses suggest a local nucleation process promoting nanocrystal growth in a supersaturated milieu. In addition, plaques contain various calcium and magnesium phosphates and not only carbonated apatite.