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Elastic waves in human kidney stones: Shear dominates spall in shock wave lithotripsy

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We investigated the role of shear waves and spall in the fragmentation of human kidney stones. Seven human kidney stones, approximately 5 mm in diameter, were scanned with micro computed tomography to obtain a 3D representation that was imported into an elastic wave code. The code was initialized with a lithotripsy waveform and the evolution of stresses and strains was tracked through space and time. The evolution of the principal stress indicated that reflection from the distal surface of the stone (spallation) did not induce large tensile stresses (<40 MPa) due to the curved geometry of the proximal and distal surfaces. Instead as the shock wave in the fluid passed the mid-section of the stone there was efficient coupling into shear waves which then propagated into the interior of the stone and generated the largest regions of high tensile stress (>60 MPa). The results indicate that for the human stones studied here shear waves generated at the stone periphery are more important than spall in generating high tensile stress. These data suggest that the focal width of a lithotripter needs to be larger than the stone in order to generate large stresses. [Work supported by NIH DK43881 and DK59933].