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Rupture of blood clots

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ABSTRACT:

Intravascular blood clots are subject to hydrodynamic shear and other forces that cause clot deformation and rupture (embolization). A portion of the ruptured clot can block blood flow in downstream vessels. The mechanical stability of blood clots is determined by the 3D polymeric fibrin network which forms a gel. Previous studies have primarily focused on the rupture of fibrin clots under tensile loading (Mode I), our current study investigates the rupture of fibrin induced by shear loading (Mode II), dominating under physiological conditions induced by blood flow. In this study, we show first that constitutive laws written for fibrin gels under tensile loading correctly capture the stress-strain response in simple shear. Second, using experimental and theoretical approaches, we show that fracture toughness, i.e. the critical energy release rate, is relatively independent of the type of loading. Ultrastructural studies and finite element simulations demonstrate that cracks propagate perpendicular to the direction of maximum stretch at the crack tip. These observations indicate that locally, the mechanism of rupture is predominantly tensile. Furthermore, our constitutive descriptions are able to capture quite well the alignment of fibrin fibers at various locations in the cracked sample, including near the crack tip, crack faces and sample edges. Lastly, we show how a knowledge of the fracture toughness and mechanism can aid in the development of methods for prediction/prevention of thrombotic embolization.

BIOGRAPHY:

Prashant Purohit is Professor of Mechanical Engineering and Applied Mechanics at the University of Pennsylvania. He got his PhD at Caltech in 2002 and after a few years of postdoctoral work he joined the faculty at Penn in 2006. His interests are in phase transitions, statistical and continuum mechanics and biophysics. His current research is focused on the mechanics and fracture of blood clots.