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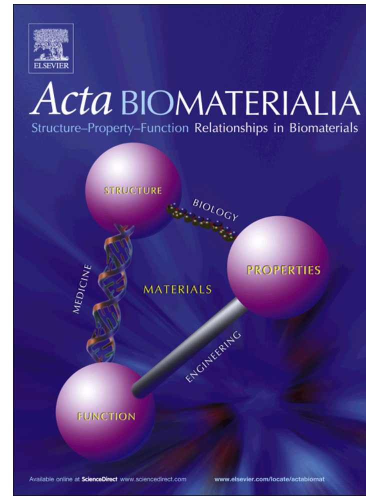

Fracture Mechanics of Shear Crack Propagation and Dissection in the Healthy Bovine Descending Aortic Media

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Fracture Mechanics of Shear Crack Propagation and Dissection in the Healthy Bovine Descending Aortic Media

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Abstract

This experimental study adopts a fracture mechanics strategy to investigate the mechanical cause of aortic dissection. Inflation of excised healthy bovine aortic rings with a cut longitudinal notch that extends into the media from the intima suggests that an intimal tear may propagate a nearly circumferential-longitudinal rupture surface that is similar to the delamination that occurs in aortic dissection. Radial and 45^o-from-radial cut notch orientations, as seen in the thickness surface, produce similar circumferential crack propagation morphologies. Partial cut notches, whose longitudinal length is half the width of the ring, measure the influence of longitudinal material on crack propagation. Such specimens also produce circumferential cracks from the notch root that are visible in the thickness circumferential-radial plane, and often propagate a secondary crack from the base of the notch, visible in the intimal circumferential-longitudinal plane. Inflation of rings with pairs of cut notches demonstrates that a second notch modifies the propagation created in a specimen with a single notch.

The circumferential crack propagation is likely a consequence of the laminar medial structure. These fracture surfaces are probably due to non-uniform circumferential shear deformation in the heterogeneous media as the aortic wall expands. The qualitative deformation morphology around the root of the cut notch during inflation is evidence for such shear deformation. The shear apparently results from relative slip in the circumferential direction of collagen fibers. The slip may produce shear in the longitudinal-circumferential plane between medial layers or in the radial-circumferential plane within a medial lamina in an idealized model. Circumferential crack propagation in the media is then a shear mechanical process that might be facilitated by disease of the tissue.

Keywords: crack propagation in aortic media; aortic shear deformation; aortic dissection and rupture; fracture mechanics; false lumen; intimal tear