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A Finite Element Study of Laminitis in Horses

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Abstract : Equine locomotion and performance are significantly affected by hoof health. One of the most critical diseases of the hoof is laminitis, which can lead to horse lameness in a severe condition. This disease exhibits the mechanical properties degradation of the laminar junction tissue within the hoof. Therefore, it is essential to investigate the biomechanics of the hoof, focusing specifically on excessive and cumulatively accumulated stresses within the laminar junction tissue. For this aim, the current study generated a novel equine hoof Finite Element (FE) model under dynamic physiological loading conditions and employing a hyperelastic material model. Associated tissues of the equine hoof were segmented from computed tomography scans of an equine forelimb, including the navicular bone, third phalanx, sole, frog, laminar junction, digital cushion, and medial- dorsal- lateral wall areas. The inner tissues were connected based on the hoof anatomy, and the hoof was under a dynamic loading over cyclic strides at the trot. The strain distribution on the hoof wall of the model was compared with the published in vivo strain measurements to validate the model. Then the validated model was used to study the development of laminitis. The ultimate stress tolerated by the laminar junction before rupture was considered as a stress threshold. The tissue damage was simulated through iterative reduction of the tissue's mechanical properties in the presence of excessive maximum principal stresses. The findings of this investigation revealed how damage initiates from the medial and lateral sides of the tissue and propagates through the hoof dorsal area.

Keywords : horse hoof, laminitis, finite element model, continuous damage
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