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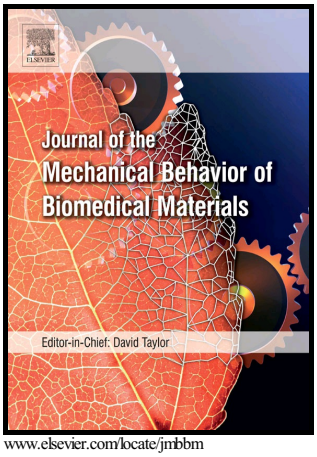

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Shear Deformations of Human Articular Cartilage: Certain Mechanical Anisotropies Apparent at Large But Not Small Shear Strains

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Abstract

Articular cartilage has pronounced through-the-thickness heterogeneity in both ultrastructure and mechanical function. The tissue undergoes a combination of large deformations *in vivo*, where shear is critical in both failure and chondrocyte death. Yet the microstructure mechanical response of cartilage to multi-axial large shear deformations is unknown. We harvested a total of 42 cartilage specimens from seven matched locations across the lateral femoral condyles and patellofemoral grooves of six human male donors (30.2 $\pm$ 8.8 yrs old, M$\pm$SD). With each specimen we applied a range of quasi-static, multi-axial large (simple) shear displacements both parallel and perpendicular to the local split-line direction (SLD). Shear stresses in cartilage specimens from the patellofemoral grooves were higher, and more energy was dissipated, at all applied strains under loading parallel to the local SLD versus perpendicular, while specimens from the lateral condyles were mechanically anisotropic only under larger strains of 20% and 25%. Cartilage also showed significant intra-donor variability at larger shear strains but no significant inter-donor variability. Overall, shear strain-energy dissipation was almost constant at 5% applied shear strain and increased nonlinearly with increasing shear magnitude. Our results suggest that full understanding of cartilage mechanics requires large-strain analyses to account for nonlinear, anisotropic and location-dependent effects not fully realized at small strains.

Keywords: human articular cartilage, large-strain shear, anisotropy,

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