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The effect of porosity on mechanical properties of ortho-metamaterial

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The current material design of orthopedic prostheses strictly consists of solid metal shaped to mimic the body part in which it is being implanted. While stainless steel, cobalt chromium and titanium have been effective in causing minimal foreign body interactions, this solid design does not accurately replicate the shape and elastic modulus of both cortical and cancellous bone. By combining the mechanical properties engineered from metamaterials with the biocompatible qualities of biomaterials, our proposed solution called "Ortho-metamaterials" will match the elastic modulus, hardness, fatigue resistance, porosity and notch-sensitivity of natural bone. Using our own unit cell to reverse engineer various structures of Generation 1, we have conducted computer simulations through SolidWorks and performed mechanical tests with 3D printed prototypes. Compression, distraction, shear and torque forces were applied to represent standing, walking, abduction/adduction, and internal/external rotation respectively in the average patient. Compared to the solid cube (current prosthetic material design) all of our designs derived from the unit cell maintained significantly higher stress values. The analyses of these results prove the development of this material is essential to the use and lifespan of orthopedic prostheses.

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