Engineering Soft Materials to 3D Print Human Kidney Models

Abstract: Every day, approximately 50 gallons of blood filter through our fist-size kidneys. In a kidney, the blood branches into roughly one million streams, and penetrates through nanoscale pores in the glomerulus. Most of this filtrate is then reabsorbed by the renal cells in tubules and merges back to the main blood stream, whereas the unabsorbed fluid and metabolic waste are released through the urethra. Bioengineered 3D kidney tissues that emulate human responses could potentially lead a revolution in drug safety testing and ultimately solve organ donor shortage issues. Unfortunately, current kidney-on-chip models lack the 3D geometry, complexity, and functionality necessary to recapitulate in vivo renal tissue. In this talk, I will discuss how we address these engineering challenges by creating 3D vascularized proximal tubule models via multimaterial bioprinting and characterizing their reabsorption properties. In particular, I will discuss how we engineer the mechanical properties of different biomaterials to construct adjacent conduits that are lined with confluent epithelium and endothelium embedded in a permeable extracellular matrix. Our 3D kidney tissue closely mimics the native microenvironment, and thus exhibits active reabsorption of solutes including albumin uptake and glucose reabsorption. Lastly, I will show a few examples of how our model enables toxicity studies and disease modeling that have been difficult to conduct using conventional in vitro systems.