3D Printing of implantable biomaterials: Scientific understanding of process science and future scope

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Biomaterials science and biomedical engineering have sustained as one among frontier and growing areas of research and innovation within the engineering science community in the world; considering the number of scientific discoveries and their societal impact. Significant attempts were largely directed to re-create functional musculoskeletal systems with considerable potential to treat various types of human diseases. At the beginning of my presentation, I will present multiscale measurements and analysis to quantitatively understand the process physics of binderjet 3D printing. I will present some of our recent results to demonstrate the efficacy of the 3D powder printing to fabricate Sr-substituted Mg-phosphate bioceramic scaffolds and Zirconia bioceramics, albeit with specific challenges. A major emphasis will be placed on the binder formulation, post-processing treatment, and micro-computed tomography of interconnected porous architecture together with the strength reliability. One of the most recent clinical translational attempts to treat decompressive craniectomy using 3D powder printed patient-specific cranial prosthesis will be presented. Towards the end, the recent results of 3D bioprinting will be presented. It will be shown as how the hydrothermally synthesized nanocrystalline needle-shaped HAp particles (<30 nm) were incorporated into pre-crosslinked gelatin methacryloyl (GelMA) hydrogel to obtain a better combination of compression strength (~ 300 kPa) and elastic modulus (~ 300 kPa) in a designed scaffold. We propose that the inorganic-organic nanocomposite hydrogel could be efficiently assembled to formulate a potential bioink for 3D bioprinting applications towards bone tissue regeneration. This lecture will close by introducing a new concept, Biomaterialomics, which brings together Biomaterials science and Data Science.