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Editorial

Editorial for the Special Issue on Medical Additive Manufacturing

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This special issue focuses on the emerging technology of additive manufacturing, also known as three-dimensional (3D) printing. This topic is derived from a keynote lecture presented at the 2019 International Summit Forum on Engineering Science and Technology Strategy: From Frontier Technology to Research and Development of Products Using Medical Additive Manufacturing. The Summit Forum was organized by the Chinese Academy of Engineering (CAE) and took place in mid-June 2019 in Shenzhen, China. The topics covered by this special issue include the research and development of raw materials, design and 3D manufacturing technologies, and the preclinical testing and clinical applications of additive manufacturing in orthopedics and related fields. The authors of the articles published in this issue are leading experts from academia, hospitals, industry, and regulatory bodies, and include fellows and academicians from the academies of science and of engineering of Canada, China, France, and the United States.

The use of 3D printing and its associated raw materials in assisting diagnosis and preoperative surgical planning, as well as designing surgical guide plates and accessories to tackle orthopedic challenges, is relatively advanced. In fact, raw materials that have been developed for medical additive manufacturing have a wide range of commonalities with those developed for use in other industrial fields. However, apart from conventional non-biological materials, such as permanent or bioinert metals, degradable polymers or polyetheretherketone (PEEK) are the most widely used materials in medical additive manufacturing, as they are biocompatible for developing Class III medical implants. New attempts are now being made to introduce magnesium and its alloys as promising—yet challenging—biodegradable metals. In addition to pure materials, homogeneous/non-homogeneous ceramic-based inorganic composite materials are being developed. Living cells and tissues are also emerging as biological materials for use in 3D bio-printing. Such efforts create great opportunities by resulting in the development of attractive approaches using innovative tissue engineering concepts. Nevertheless, ethical concerns arise in the bedside application of such approaches when living cells are involved. In ongoing research, materials are being combined with antibacterial drugs to grant the materials antibacterial properties with great clinical application potential.

As 3D printing technologies and applications are multidisciplinary in nature, 3D printing machines should be designed by bringing together applications and desired materials from the very beginning, through collaborative efforts among engineers, material scientists, and clinical scientists. Some of the reasons why such multidisciplinary development is necessary include: ① Conventional 3D printing puts new demands on the R&D of materials and biomaterials in powder forms; ② emerging 3D bio-printing places greater demands on the spatial distribution of different materials and living cells, as optimized using bio-ink; and ③ a material's processing properties and mechanical properties must be considered prior to its 3D printing manufacturing process, especially when designing personalized medical implants with varying mechanical demands (e.g., matching the geometry and structure to the host tissue or organ, as in hip reconstruction and bone tumor reconstruction surgery).

For this special issue, we selected articles that were relevant to the previously discussed challenges in the field of medical additive manufacturing. These works provide details on the current status, opportunities, and challenges in this field:

(1) Advances in medical applications of additive manufacturing;

(2) Microfluidics for medical additive manufacturing;

(3) Development of bio-implants with 2D, 3D, and 4D additive manufacturing materials;

(4) 3D printing of cell-container-like scaffolds for multicell tissue engineering;

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(5) A systematic approach for making 3D printed patient-specific implants for craniomaxillofacial reconstruction;

(6) Challenges and solutions for the additive manufacturing of biodegradable magnesium implants;

(7) 3D printing hip prostheses offer accurate reconstruction, stable fixation, and functional recovery for revision total hip arthroplasty with complex acetabular bone defect;

(8) A review of the application of additive manufacturing in prosthetic and orthotic clinics from a biomechanical perspective.

We anticipate that this special issue on additive manufacturing and 3D printing in orthopedics and related fields will effectively facilitate international collaborations, similar to that of the aforementioned forum. These platforms will allow us to develop better materials, design and manufacture novel technologies, and establish relevant and validated clinical indications, with the ultimate goal of benefiting patients through improved medical efficacy and safety.