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ADDITIVELY MANUFACTURED POROUS BIOMATERIALS AND IMPLANTS

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Background

Recent advances in additive manufacturing (AM) techniques (otherwise known as 3D printing) have enabled fabrication of a new class of porous biomaterials (Figure 1) with arbitrarily complex and precisely controlled topologies that e.g. resemble the geometry and micro-architecture of (trabecular) bone. Since the geometry of scaffolds and biomaterials is an important factor in bone tissue regeneration [1], freedom in topological designs presents many opportunities for improving bone regeneration performance of biomaterials and osseointegration of implants. AM porous biomaterials can be made from various biocompatible metals including titanium, tantalum, and stainless steel, and can be used either as (a part of) orthopaedic implants or as bone substitutes.

Recent Advances

Recent research on AM porous biomaterials can be categorized into three major categories. First, several studies have tried to utilize the freedom in topological design offered by AM techniques to adjust the mechanical behaviour and bone regeneration performance of biomaterials. For example, we have shown that, by rational design of porous biomaterials, mechanical properties close to bone and even less could be obtained from very stiff metallic alloys [2]. Moreover, we found both the static mechanical properties [2] and fatigue behaviour [3] of porous biomaterials to be strongly dependent on their topological design including not only the porosity and pore shape but also the geometry of the repeating unit cell. Second, we introduced surface nano-topographies on top of the huge surface area of AM porous biomaterials and showed that they significantly improve the bone regeneration performance of AM porous materials [4]. Finally, we used the pore space available in AM porous biomaterials to deliver growth factors that stimulate bone regeneration and vascularization [5].

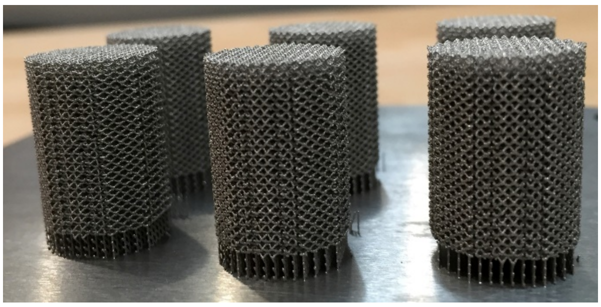

Figure 1: Some examples of AM metallic porous biomaterials fabricated in my lab.

Amir Zadpoor is an Associate Professor and Chair of Biomaterials and Tissue Biomechanics section at TUDelft. He obtained his PhD cum laude from the same university and immediately started to work as a faculty member at Department of Biomechanical Engineering where he currently leads a large group of researchers. His research interests include 3D printed multi-functional biomaterials, (patient-specific) orthopedic implants, tissue biomechanics, mechanobiology of the skeleton, and skeletal imaging. He is the recipient of several international awards including an ERC grant, serves on the editorial boards of multiple journals, has organized several international meetings, and has published >100 scientific articles.

In a recent study, we demonstrated that by proper combination of the three above-mentioned approaches including topological design, surface treatments, and local drug delivery, it is possible to fully regenerate bone and restore functionality in critical-sized load-bearing bony defects [6].

Future directions

There are several developments that are needed for further improvement of AM porous biomaterials. First, it is important to manufacture biodegradable porous biomaterials and study how the topological design influences the biodegradation process and its products. There is currently limited research on biodegradable AM porous biomaterials partly due to the fact that additively manufacturing of some of the most commonly used metallic alloys such as magnesium alloys remains challenging. Second, the huge surface area and pore space could be also used for a different purpose, i.e. combating implant-related infection. Not much research has been performed on the latter topic either.

References

1. Zadpoor, Biomaterials Science, 3:231-245, 2015.
2. Campoli et al, Materials & Design 49:957-965, 2013.
3. Yavari et al, J Mech Behav Biom Mater 43:91-100, 2015.
4. Yavari et al, Biomaterials 35:6172-6181, 2014.
5. Van der Stok et al, Tissue Eng A 19:2605-2614, 2014.
6. Van der Stok et al, Europ Cell Mater, 29:141-154, 2015.

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