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Abstract

The Role of Unit Cell Geometry on Biocompatibility of β-Ti Lattice Scaffolds

M. Babaei[1*], L. Emanuelli[2], R. De Biasi[1], A. Trivisonno[3], G. Dall'Amico[3], F. Riva[3], M. Benedetti[1], and M. Pellizzari[1]

[1] *Department of Industrial Engineering, University of Trento, Trento, Italy*
[2.] *INSTM Operative center: University of Trento, Trento, Italy*
[3.] *Trumpf Additive Manufacturing Italia s.r.l, Schio, Vicenza, Italy*
[*] *Corresponding author, email: melika.babaei@unitn.it*

Due to advancements in additive manufacturing (AM), numerous scientific fields have shown keen interest in utilizing this method to streamline production, enhance product quality, and minimize defects. Biomedical applications, in particular, have widely embraced AM for fabricating organ substitute implants. For example, the production of metal alloy scaffolds for orthopedic implants has shifted towards this approach [1]. The exceptional mechanical properties, high corrosion resistance, and biocompatibility of Titanium (Ti) alloys have made them the most commonly used biomaterials for bone tissue substitutes. However, the presence of toxic elements like Aluminum (Al) and Vanadium (V) in first-generation implants (such as Ti-6Al-4V or Ti-6Al-7Nb) has led to a growing interest in second-generation Ti alloys, specifically Beta-Ti alloys, in the past decade [2]. While the solid use of Beta-Ti alloys results in a significantly higher elastic modulus than that of bone, leading to a stress-shielding effect upon implantation, this issue can be addressed by designing porous materials. This design approach significantly reduces the stress-shielding effect and the Young's modulus. Using porous materials also benefits the *in vitro* behavior of cells cultured on the implant. When producing porous bone tissue replacements, selecting an optimal pore size is crucial for cell proliferation and ingrowth. This consideration is particularly important for load-bearing Ti-based implants. The successful integration of an implant into bone tissue and prevention of post-surgical loosening depend on proper cell proliferation, and ingrowth into the implant. Studies have highlighted porosity and pore size as the primary properties of Ti structures related to osteointegration. This study aims to develop and evaluate a porous bone substitute made of βTi21S material to enhance the body's biological response to the implant and promote superior osteointegration compared to non-porous scaffolds. Two distinct lattice unit cells, an auxetic sheet-based lattice with pore sizes of 500 µm and 600 µm, and a TPMS beam-based lattice with pore sizes of 600 µm and 900 µm, were designed using nTopology software to investigate the influence of pore size and geometry on *in vitro* assays. The samples were fabricated using the laser powder bed fusion method with βTi21S powder. The LDH cytotoxicity assay assessed material toxicity on MRC-5 fibroblast human cells under various conditions, while the metabolic analysis using the Alamar blue assay examined the proliferation behavior of MG-63 osteosarcoma cells. Confocal microscopy was employed to analyze the morphology of MG-63 cells at different time points. By comparing different pore sizes within similar lattice designs, the impact of pore size on cell behavior was assessed. Furthermore, various designs were compared based on samples with identical pore size dimensions.

AUTHOR'S STATEMENT

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REFERENCES

[1] R. Kumar, M. Kumar, and J. S. Chohan, "The role of additive manufacturing for biomedical applications: A critical review," Journal of Manufacturing Processes, vol. 64. 2021. doi: 10.1016/j.jmapro.2021.02.022.
[2] F. Brunke, C. Siemers, and J. Rösler, "Second-generation Titanium alloys Ti-15Mo and Ti-13Nb-13Zr: A comparison of the mechanical properties for implant applications," MATEC Web of Conferences, vol. 321, 2020, doi: 10.1051/matecconf/202032105006.

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