Transactions on Additive Manufacturing Meets Medicine
Trans. AMMM, 2025, Vol. 7, No 1, Suppl. 1, Article ID 2083, 1 Page

Infinite Science Publishing

*Abstract*

# Patient-specific tibia implants: Computational design and testing processes for clinical cases

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The surgical treatment of critical-sized bone defects with complex three-dimensional geometries is a challenge for the treating surgeon. Additive manufacturing technologies, such as 3D printing, enable the production of highly individualized bone implants. This includes different challenges such as meeting the shape of the patient's bone defect, an adequate mechanical stability and a tunable internal lattice structure [1]. Although the technologies for 3D printed implants have greatly progressed, clinically relevant workflows are not yet established in trauma surgery. The ideal implant design must provide mechanical stability, as well as material and design related features to support biologization. In this study, we showcase the design process of specific implants for patients with critical-sized tibia defects.

Appropriate clinical cases with severe bone defects were selected and Brainlab [2] software was used for segmentation of CT data to generate 3D models of the defects. The model was then filled with Voronoi, Gyroid, and NaCl crystal lattice structures. Variations in pore size were accomplished by adjusting unit cell size and wall/beam thickness. The designed implants and test bodies were printed from resin (clear V4, SLA printer Form 3). Test bodies were compression tested to gather data for subsequent finite element analysis of the designed implant.

In this proof-of-principle study customized tibia implants fitting the individual bone defects of the patients were successfully generated and printed as model implants from resin. Further studies will include more patient datasets to refine the workflows and digital tools for a broader spectrum of bone defects. Additional mechanical testing and finite element analysis will be used to improve the prediction of mechanical properties and to evaluate mechanical properties of different lattice structures or pore sizes in individual implants. Results from resin-based implants will be transferred using biomedical suitable materials, such as 3D printed ceramic materials for instance.

## Author's Statement

Conflict of interest: Authors state no conflict of interest. Informed consent: Informed consent has been obtained from all individuals included in this study. Ethical approval: The research related to human use complies with all the relevant national regulations, institutional policies and was performed in accordance with the tenets of the Helsinki Declaration, and has been approved by the authors' institutional review board or equivalent committee. Acknowledgments: The Research funding: We thank the CAU for funding part of this work by "Validierungsfond"

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DOI: 10.18416/AMMM.2025.25062083