Transactions on Additive Manufacturing Meets Medicine
Trans. AMMM, 2026, Vol. 8, No 1, Suppl. 1, Article ID 2736, 1 Page

Abstract

Additively manufactured bone surrogates for reproducing screw insertion behavior in cadaveric bone

M. Hach[1*], A. Klostermann[1], M.L. Königer[2], B. Zeller-Plumhoff[3], T. Mittlmeier[2], and P. Weißgraeber[1]

[1] *Chair of Lightweight Design, University of Rostock, Rostock, Germany*
[2] *Dept. of Trauma, Hand and Reconstructive Surgery, Rostock University Medical Center, Rostock, Germany*
[3] *Data Driven Analysis and Design of Materials, University of Rostock, Rostock, Germany*
[*] *Corresponding author, email: mathis.hach@uni-rostock.de*

Reliable preclinical testing of orthopedic implants in osteoporotic bone remains challenging because cadaveric specimens show substantial inter-specimen variability and limited availability [1]. This is particularly problematic for screw-based fixation, where local bone architecture strongly affects anchorage and insertion behavior. Bone surrogates therefore offer considerable potential for establishing more reproducible test environments [2-3].

The present study investigates whether additively manufactured bone surrogates can reproduce the screw insertion behavior of osteoporotic cadaveric bone. First, instrumented screw insertion tests were performed on cadaveric bone from aged body donors, using the distal radius as an example application, in order to characterize the characteristic torque–angle response during screw insertion. Then, surrogate specimens were manufactured by stereolithography from a rigid photopolymer resin. These specimens consist of a sandwich structure with solid regions at the top and bottom, representing cortical bone and a lattice-based trabecular architecture with varying relative densities in between. The same screw insertion experiments were then performed on the printed specimens using a dedicated test bench, and the resulting torque–angle curves were compared with the cadaveric reference and analytical model predictions.

The additively manufactured surrogates exhibited torque–angle profiles with similar curve morphology to those observed in osteoporotic cadaveric bone. Quantitative parameters derived from the insertion process, including peak torque and torque rise characteristics, also showed close agreement. Beyond implant testing, the surrogates show potential as training devices, given their ability to replicate the haptic feedback of surgical procedures such as screw insertion, offering a reproducible and ethically accessible alternative to cadaveric material. This study is limited by the small number of specimens, particularly regarding cadaveric bone samples, and does not yet include pull-out strength characterization, which would be a valuable metric for assessing implant fixation. Future work should therefore investigate pull-out strength in both cadaveric and surrogate specimens to enable a more comprehensive mechanical comparison.

AUTHOR'S STATEMENT

Conflict of interest: Authors state no conflict of interest. Informed consent: No human participants were involved in this project.

REFERENCES

[1] Oldham, Blaine, et al. "The current state of biomechanical analyses of the adult human femur: A systematic review." *Journal of the Mechanical Behavior of Biomedical Materials* (2025): 107158.
[2] Hollensteiner, Marianne, Andreas Traweger, and Peter Augat. "Anatomic variability of the human femur and its implications for the use of artificial bones in biomechanical testing." *Biomedical Engineering/Biomedizinische Technik* 69.6 (2024): 551-562.
[3] Zdero, Radovan, Pawel Brzozowski, and Emil H. Schemitsch. "Biomechanical properties of artificial bones made by Sawbones: a review." *Medical engineering & physics* 118.1 (2023): 104017.

DOI: 10.18416/AMMM.2026.26062736