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Development of materials for additively manufactured hybrid knee implants

M. Weinmann[1*], M. Stenzel [1], J. Johannsen[2], J.-O. Sass[3], M.-L. Sellin[3], C. Lork[4], D. Pfützner[5], U. Lembke[6], D. Kluess[3,7], and R. Bader[3]

[1] Taniobis GmbH, Im Schleeke 78-91, D-38642 Goslar, Germany
[2] Fraunhofer IAPT, Am Schleusengraben 14, D-21029 Hamburg, Germany
[3] Department of Orthopedics, Rostock University Medical Center, Doberaner Straße 142, D-18057 Rostock, Germany
[4] Tizio Hybrid Implants GmbH, Breite Straße 16, D-18055 Rostock Germany
[5] FMZ GmbH, Charles-Darwin-Ring 3a, D-18059 Rostock, Germany
[6] DOT GmbH, Charles-Darwin-Ring 1a, D-18059 Rostock, Germany
[7] INNOPROOF GmbH, Joachim-Jungius-Straße 9, D-18059 D-Rostock, Germany
[*] Corresponding author, email: markus.weinmann@taniobis.com

The present work focusses on the development of a functional demonstrator for hybrid knee implants based on newly additively manufactured bio-tolerant Ti/Nb/Ta (TNT) alloys connected to an Al_2O_3-toughened ZrO_2 (ATZ) ceramic component using glass soldering technology. Both mechanical test and biological analysis were carried out.

A series of TNT alloy powders exhibiting excellent processability and homogeneous element distribution was developed for use in Laser Powder Bed Fusion (L-PBF) processes [1]. Extensive studies on the 3D printing parameters confirmed their excellent printability, resulting in densities of the 3D-manufactured parts of > 99,97% rel. density. Compression and tensile tests of the printed material showed both very high elasticity and ductility of the TNT samples combined with appropriate strength, i.e. UTS of at least 650 MPa under tension [2].

Mechanical functionality was assessed by the ratio of modulus to yield strength (elastic admissible strain). As-printed TNT samples (0° or 90° build orientation; Ti6Al4V as reference) supported osteogenic differentiation of human osteoblast while no inflammatory processes were induced.

Finally, a functional demonstrator of a hybrid total knee implant was additively manufactured. The printed TNT part was connected to a powder metallurgically produced ATZ ceramic component by means of soldering with a specific silicate glass. [3] The hybrid material made of TNT alloy and ATZ ceramic did not affect the osteoblastic viability in contrast to reference samples made of Co28Cr6Mo.

AUTHOR'S STATEMENT

Conflict of interest: M. Weinmann and M. Stenzel are emplyees of Taniobis GmbH; C. Lork is employee of Tizio Hybrid Implants GmbH; D. Pfützner is employee of FMZ GmbH; U. Lembke is employee of DOT GmbH; D. Kluess is engaged with INNOPROOF GmbH. 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.

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