# 3D printing of personalized, absorbable metallic implants

## Forskningsleder Holger Jahr

Over 2.4 billion people globally need rehabilitation. Musculoskeletal disorders alone affect 1.71 billion - and that number is still climbing. Future healthcare needs better tools: meet the implant with an exit strategy.
Bioabsorbable metals (magnesium, zinc) and polymers (PLA, PLGA, PCL) are reshaping what an implant can be - not a permanent foreign body, but a temporary scaffold that does its job and gracefully disappears. No biofilm, no stress shielding, no revision surgery - just natural tissue remodeling.

Additive manufacturing (a.k.a., 3D printing) is driving an unprecedented shift in bone healing, moving away from "one-size-fits-all" titanium implants toward customized, bioactive, and bioabsorbable scaffolds that encourage natural bone regeneration. These 3D-printed scaffolds are meticulously designed to mimic real bone structures, improving healing speed and enhancing integration with native tissue.

Additive manufacturing (AM) technologies make this personal: from a patient's CT-scan to a custom-printed, porous, bone-mimicking structure - geometry tuned for cell infiltration, vascularization, and tissue integration. The future of implants isn't permanent. It's purposefully temporary. AM has enabled the creation of "supranatural" or bioinspired designs - structures that exceed the performance, complexity, and capabilities of traditional materials and geometries found in nature. By using AM to fabricate complex geometries, such as metamaterials, "supernatural strength" can be achieved and functional properties that outperform conventional, homogeneous materials. Absorbable metal implants are already FDA-approved Medical Devices for example in cardiovascular applications, like bioresorbable stents that prop open arteries for 1–3 years, then vanish, restoring natural vessel function (Medtronic patent WO2008118607A3; PROGRESS-AMS clinical trial).

In **Orthopaedics** biodegradable fixation devices and bone scaffolds and in **Odontology,** patient-specific alveolar scaffolds guiding periodontal and bone regeneration are envisioned. The connective thread: medical imaging and absorbable materials and AM precision = implants that work with biology, not against it. *Ex vivo* organ-on-a-chip testing bridges lab innovation and clinical reality – validating degradation kinetics, biomechanics, and biocompatibility before anything goes near a patient. This is how materials science, biomechanics, and medicine converge into something genuinely translational. The market is enormous. The need is urgent. The **technology is ready to play.**

### Methods

- Additive manufacturing of topology-optimized Mg/Zn alloy implants, with tailored surface modification for corrosion control.
- Mechanical characterization under physiological conditions and *in vitro* cytocompatibility screening – reducing reliance on animal models.
- Computational modeling of degradation kinetics and tissue response, with emphasis on oxidative stress pathways, 3D organoid-based biomineralization, and omics analyses for biomarker discoevery.

Er du interesseret i at skrive projekt i gruppen, så kontakt – **in English**:
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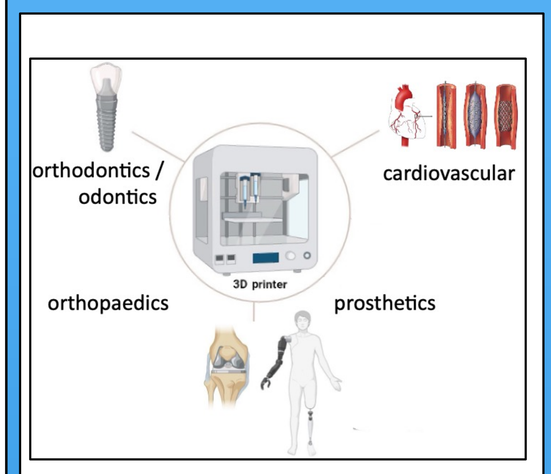


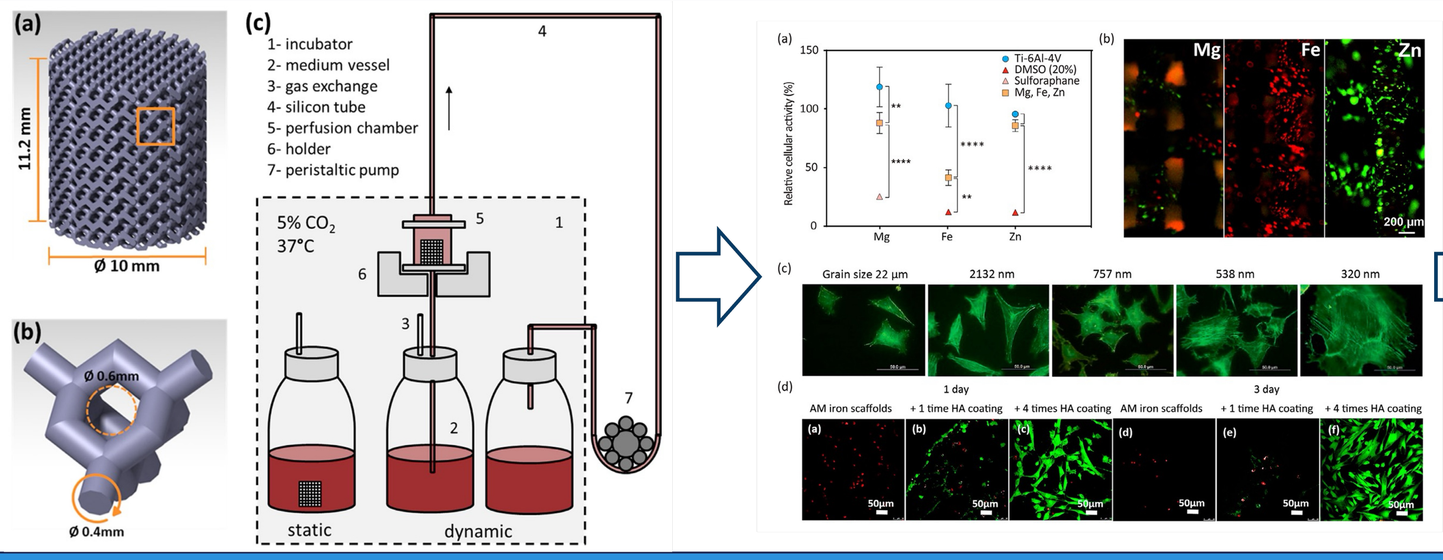


| Projekter | Beskrivelse |
|---|---|
| **Cytocompatibility of AM absorbable implants** | Assess cell adhesion, viability, and early differentiation on (porous) metal scaffolds. Use standard assays (live/dead staining, metabolic activity, basic biomarkers) comparing different designs and/or porosities. |
| **Characterization of degradation kinetics of such implants in physiomimetic systems** | Study effects of medium flow, oxygen tension, and pH on corrosion rate and develop FE-model to predict in vivo kinetics. The long-term goal is to predict in vivo behaviour ex vivo to better meet 3R rules. |
| **Biomaterial-related oxidative stress** | Investigate how Nrf2/ARE signalling in bone, or dense connective tissue, cells responds to mechanical loading and exposure to degradation products from absorbable metallic implants. Combine in vitro models and 3D cell cultures. |