E.CH.O.
Mechano-Hybridscaffold for the endochondral ossification of large bone and bone-cartilage defects

Federal Ministry of Education and Research

INNOTERE biomaterial · matricel · JULIUS WOLFF INSTITUT · Fraunhofer ILT

INTRODUCTION

Collagen scaffolds are well known for their regenerative potential. However, the relatively poor mechanical properties, represent a problem for the translation into a clinical setting. In this study, we present a novel approach: A Mechano-Hybrid-Scaffold (MHS) that combines a collagen-based biomaterial with highly aligned channel-like pores with a 3D printed poly(ε-caprolactone) (PCL) support structure [1], overcoming contradictory requirements for mechanical stiffness and scaffold architecture. The collagen scaffolds internal architecture is preserved against cell- and tissue forces while maintaining the scaffold´s ability for cell recruitment and extracellular matrix alignment.

Scientific Problem

- No pure biomaterial approach exists for the regeneration of large bone defects
- A collagen scaffold with channel-like pores has shown to induce bone healing through **endochondral ossification** (EO)
- However, the low mechanical stiffness of the material is not suitable for a clinical application

Solution

- Mechano-Hybrid-Scaffold (MHS) that combines a collagen-based biomaterial with highly aligned channel-like pores with a 3D printed poly(ε-caprolactone) (PCL) support structure
- Macro-porous support structure serves as stabilizing element against cell and tissue forces in combination with clinically applied bone fixation systems.
- Biomaterial is available “off the shelf” and avoids high costs and regulatory limitations associated with cell- and growth factor-based approach

Partners

- Matricel GmbH - Aachen
- Julius Wolff Institut, Berlin Institute of Health at Charité (BIH) - Berlin
- INNOTERE GmbH - Radebeul
- Fraunhofer Institute for Laser Technology - Aachen

Duration

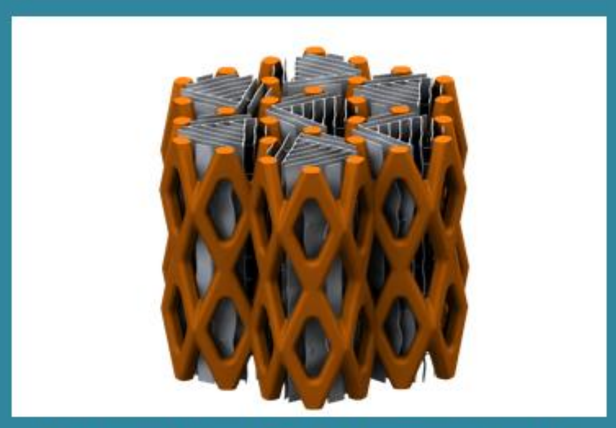
01. Jan 2018 – 31. Dec 2021

Founding No. (FKZ)

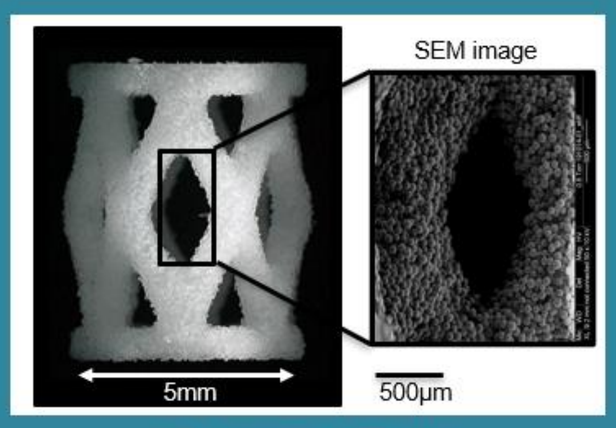
13XP5048

Results

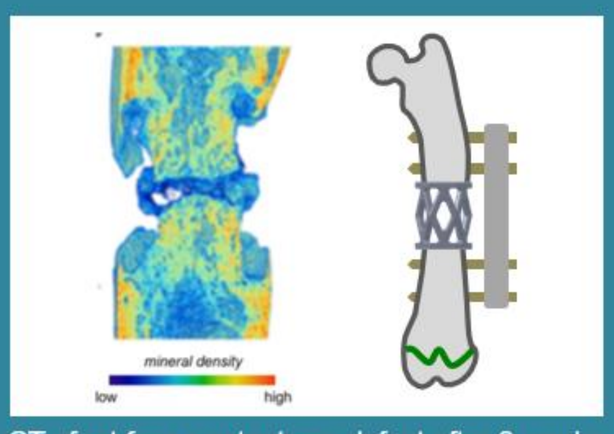
- Pore morphology (pore-alignment and pore diameter) was comparable between the pure collagen scaffold and Mechano-Hybrid-Scaffolds.
- Compared to pure collagen scaffolds Mechano-Hybrid-Scaffolds showed an increase in stiffness by three orders of magnitude (from kPa to MPa-range).
- Studies in a critical size bone defect in the rat femur show EO across the entire defect after 9 weeks.



Mechano-Hybrid-Scaffold computer model



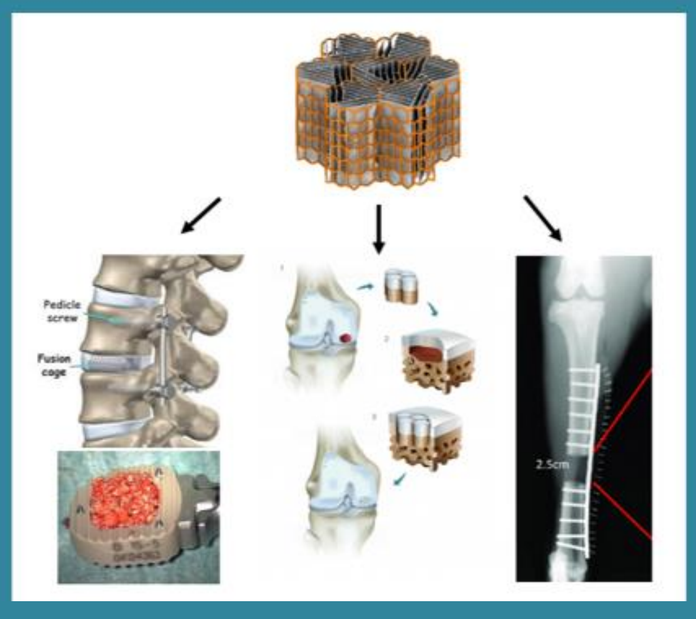
PCL supporting structure



µCT of rat femur osteotomy defect after 9 weeks

Utilization of Results/ Perspective

- Mechano-hybrid-scaffold represents a purely material-based approach to support the healing of large bone defects using the EO regeneration pathway
- Potential applications are:
  - Spinal fusion
  - Osteochondral defect
  - Long bone defects



Publications:
https://doi.org/10.1016/j.msec.2021.111986
https://doi.org/10.3389/fbioe.2021.642217
https://doi.org/10.1016/j.msec.2019.109760

Poster presentations:
- Tortorici et al., Hybrid scaffolds for architecture-induced endochondral healing of large bone defects, 30th Annual Meeting of the European Society for Biomaterials (ESB), 9-13 September 2019, Dresden, Germany
- Stadter et al., In vitro characterization of ion-doped silicate microparticles for endochondral bone regeneration, Symposium of the Berlin-brandenburg School for regenerative Therapies (BSRT), Berlin, 05.12.2019
- Implementation of a computational model to understand the strain-dependent healing of an osteochondral defect, Symposium of the Berlin-Brandenburg School for regenerative Therapies (BSRT), Berlin, 28.-30.11.2018

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