Smart NiTi constructs for 3D cell culture applications

W. Hoffmann[1,2], T. Bormann[1], F. Schlottig[3], M. Mertmann[4], I. Martin[2], D. Wendt[2], M. de Wild[1]

[1] Institute of Medicinal and Analytical Technology, University of Applied Sciences Northwestern Switzerland, Muttenz, CH. [2] Institute for Surgical Research and Hospital Management, University Hospital Basel, Basel, CH. [3] Thommen Medical AG, Waldenburg, CH. [4] Memry GmbH, Weil am Rhein, DE

INTRODUCTION: NiTi shape memory alloys have unique mechanical and physicochemical properties that are appealing for a wide variety of biomedical applications. Selective laser melting (SLM) is a versatile method to create porous scaffolds using computer aided design (CAD) [1]. With the ultimate goal of fabricating complex 3D NiTi implants for orthopaedic & dental applications, we validated the utilization of SLM-based NiTi constructs as scaffolds for Tissue Engineering applications. Targeting the beneficial properties, i.e. pseudoelasticity or the one- and two-way shape memory effect, NiTi scaffolds might be used as mechanically active implants stimulating the surrounding tissue and thereby assisting bone healing.

METHODS: We assessed the biocompatibility of NiTi scaffolds as well as the adhesion and proliferation of human bone marrow-derived mesenchymal stromal cells (hBMSC) and MG-63 osteosarcoma cells. The cells were cultured on rapid prototyped (RP) NiTi constructs both on two-dimensional disks and three-dimensional scaffolds. Cell adhesion on constructs was assessed both using SEM and confocal laser scanning microscopy (CLSM). Proliferation rates were assessed using the CyQUANT® Cell Proliferation Assay to determine cell numbers for several points in time.

RESULTS: Both cell types did not exhibit a cytotoxic effect cultured in extracts of NiTi constructs (data not shown). Following, MG-63 cells and hBMSC were seeded on 2D disks and 3D NiTi scaffolds revealing high colonization densities (Figure 1). Additionally, long-term cultures up to 21 days were performed in order to investigate hBMSC proliferation capacity cultured on NiTi constructs. hBMSC do proliferate on NiTi constructs with similar growth rates as on tissue culture plastic (TCP) (table 1) demonstrating that SLM-NiTi disks are permissive to cell proliferation. hBMSC indicate similar sprouting and cell adhesion behaviour as observed on TCP being the gold standard in vitro culture system. These findings indicate the high biocompatibility of NiTi constructs facilitating their further utilization as cell culture substrate.

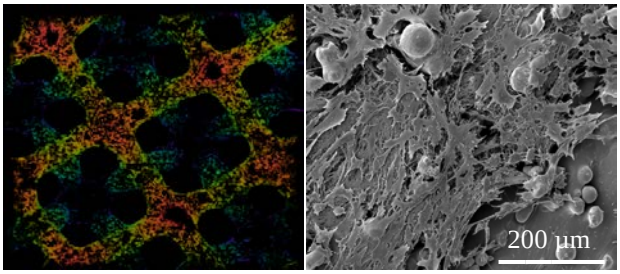

Fig. 1: Left: CLSM image of MG-63 cells cultured on a 3D NiTi scaffold (scale 3.4 mm x 3.4 mm). Right: SEM image of hBMSC cultured on 2D NiTi disk for 11 days.

Table 1. hBMSC growth rates [doublings/day].

NiTi 2D disk	TCP
0.170 ± 0.021	0.170 ± 0.033

DISCUSSION & CONCLUSIONS: The results demonstrate SLM-NiTi construct biocompatibility and underline their possible utilization as implant and/or scaffolding material exhibiting high colonization (adhesion and proliferation) capacities. Taking their unique shape memory properties into account, SLM-NiTi constructs could lead to personalized implants which allow for colonization and differentiation of host progenitors and at the same time might provide a unique platform to create active and thus *smart* implants.

REFERENCES: [1] Bormann et al (2012) Tailoring selective laser melting process parameters for NiTi implants, *J. Mater. Eng. Perform.* **21**:*12.*

ACKNOWLEDGEMENTS: The authors gratefully acknowledge the financial funding of the Swiss National Science Foundation within the research program NRP 62 “Smart Materials”.