PEEK Substrates for Measurement of Contractile Cell Forces of Primary Cells

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INTRODUCTION: Polyetheretherketone (PEEK) gains increasing interest as biomaterial for traumatologic, orthopaedic and spinal implants.[1] The PEEK-cell interactions should be optimized tailoring chemistry, morphology and rigidity of the substrate. These parameters influence the attached cells, directly observable by their shape and gene regulation.[2] Adherent cells exert contractile forces via their actin cytoskeleton and integrin-mediated focal adhesions. To quantify these contractile cell forces as the function of substrate preparation using cantilever bending is the aim of our project. Starting from commercially available medical grade PEEK, substrate modifications by plasma treatment have been developed. To study cytocompatibility, cell lines (rat-2 and mouse 3T3 fibroblasts) and human primary cells (i.e. dermal microvascular endothelial cells/HDMEC and adipose tissue-derived stem cells/ASC) were exposed to the modified PEEK substrates.

METHODS: Hot embossing of the PEEK foils was performed at the glass transition temperature of 143°C and a pressure of 100 kN. Subsequently, the embossed foils were ammonia or oxygen/argon plasma treated (100 W, 30 sccm), before cell seeding (2 x 10^4 cells/cm^2). ASC were isolated from liposuction-derived adipose tissue, HDMEC from juvenile foreskin. Cell cultivation was under standard conditions (i.e. 37°C, 5% CO_2). Cells were cultured 48 h on the PEEK substrates and subsequently depicted by the fluorescence stainings Calcein-AM (vital stain) and Hoechst 33342 (nuclear stain).

RESULTS: As primary cells are especially relevant in biomaterials research, the effect of plasma treatment on HDMECs and ASCs besides cell lines was studied. Microscopic images of the stained cells, as represented in Fig. 1, indicated that plasma treatments positively influenced cell attachment and proliferation. Plasma treatment induced similar cellular phenotypes as on tissue culture polystyrene (TCPS). Interestingly, the cell lines did not show this effect in the same specificity.

DISCUSSION & CONCLUSIONS: Our still preliminary results demonstrated that primary cells attach and spread appropriately on plasma-treated PEEK substrates. Other substrate modifications, such as micro-grooves fabricated by hot embossing induced cell alignment. Clinically more relevant replicas from sandblasted and acid-etched Ti disks with pre-defined roughness were also produced. Using contractile cell force measurements we are going to take advantage from a physical method to optimize the cell-substrate interactions for future polymeric implants.

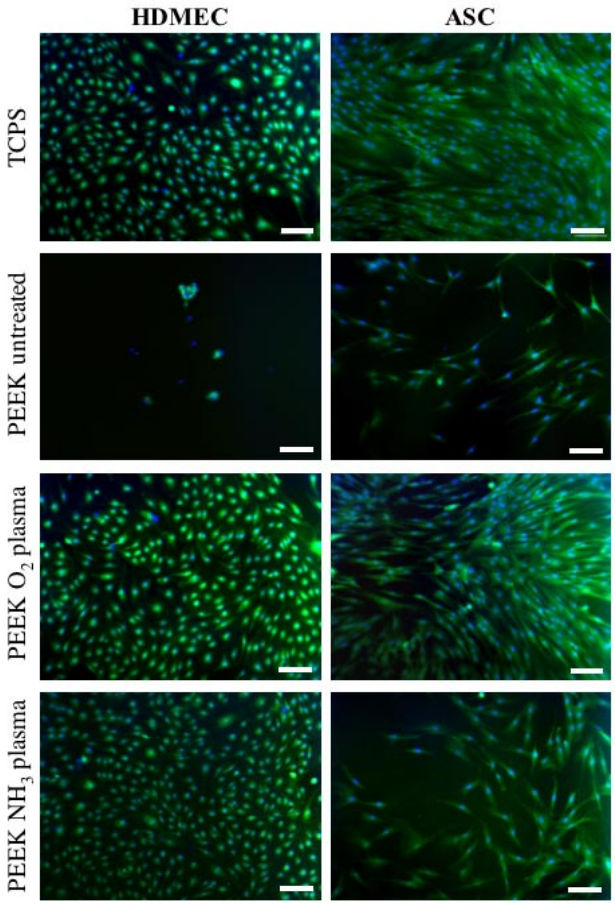

Fig. 1: Primary cells on plasma-treated PEEK and on TCPS, used as reference (green: vital staning with Calcein-AM, blue: nuclei, scale bar: 100 µm)

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