The Effect of Micro-textured CoCrMo-carbide Surfaces on the Attachment and Viability of Osteoblast-like MG63

Stacey J. L. Sullivan[1], Angela Au[2], Mark Grzanna[2], Tu Anh Pham[1], Carmelita Frondoza[2], L. D. Timmie Topoleski[1]
University of Maryland, Baltimore County[1]; Nutramax Laboratories, Inc. [2]

Statement of Purpose: In the UMBC Laboratory for Implantable Materials and Biomechanics (LIMB) we developed a micro-textured, hard carbide surface on CoCrMo implant alloys [1]. The purpose of the micro-textured surface is to improve wear performance. As an initial investigation on the biocompatibility of the LIMB micro-textured CoCrMo-carbide surface, the attachment and viability of osteoblast-like MG63 cells was determined. Cells were propagated on three different LIMB CoCrMo-carbide specimen types.

Methods: CoCrMo-carbide surfaces were grown from ASTM F 1537 disks using microwave plasma-assisted chemical vapor deposition (MPCVD) [1]. The average surface roughness (R_a) was measured by white light interference surface profilometry (WLISP). Three CoCrMo-carbide surfaces were tested: 2HR Carbide (Fig 1e, CoCrMo processed for 2 hours using MPCVD), Polished Carbide (Fig. 1b, a 2HR specimen polished after MPCVD), and Masked Carbide (Fig. 1c & 1d, a 2HR specimen masked by quartz during the MPCVD process). Borosilicate glass coverslips and polished as-received CoCrMo were used as control materials for field emission scanning electron microscope (FESEM) imaging.

Cells were propagated in a Dulbecco's modified Eagle's medium: Nutrient Mix F-12 (DMEM/F-12, containing 15 mM HEPES, L-glutamine, and pyridoxine hydrochloride). The media was supplemented with 10% heat-inactivated fetal bovine serum, sodium bicarbonate (1.5 g/L), and sodium pyruvate (1.0 mM). Cells were harvested by trypsinization at confluence.

Test material specimens were plated with MG63 cells at a density of 2 x 10^5 cells/surface. Cells were incubated for 5 days in a humidified, 37°C, 5% CO_2 environment. Glass coverslips were viewed under a light microscope to confirm confluence. Cell viability and attachment on CoCrMo disk surfaces could not be confirmed prior to cell fixation due to the opaque nature of the CoCrMo disks. Specimens were transferred to new plates for cell fixation and FESEM imaging.

Results: Cells cultured on Polished CoCrMo (Fig. 1a) appeared confluent and well defined with a flat polygonal morphology and numerous microvilli; similar to cells grown on glass coverslip. The 2HR surface (Fig. 1e) did not appear confluent with cells, but instead cells grew in closely spaced clusters across the specimen. Within each cluster, cells had well defined morphology, microvilli and cytoplasmic extensions.

Polishing of the 2HR specimen resulted in an R_a only slightly lower than the R_a of the original 2HR surface, however, large smooth areas (orange, local R_a = 0.087 ± 0.050 µm) were present where the top peaks had been polished off. Cell growth on the Polished Carbide (Fig. 1b) and the Masked Carbide: Polished area (Fig. 1c) had a similar appearance to the Polished CoCrMo (Fig 1a). Cell growth on the Masked Carbide: Carbide area (Fig. 1d) more closely followed the growth pattern of the 2HR surface, where cells grew across the specimen with some vacant areas and overall, appeared slightly denser.

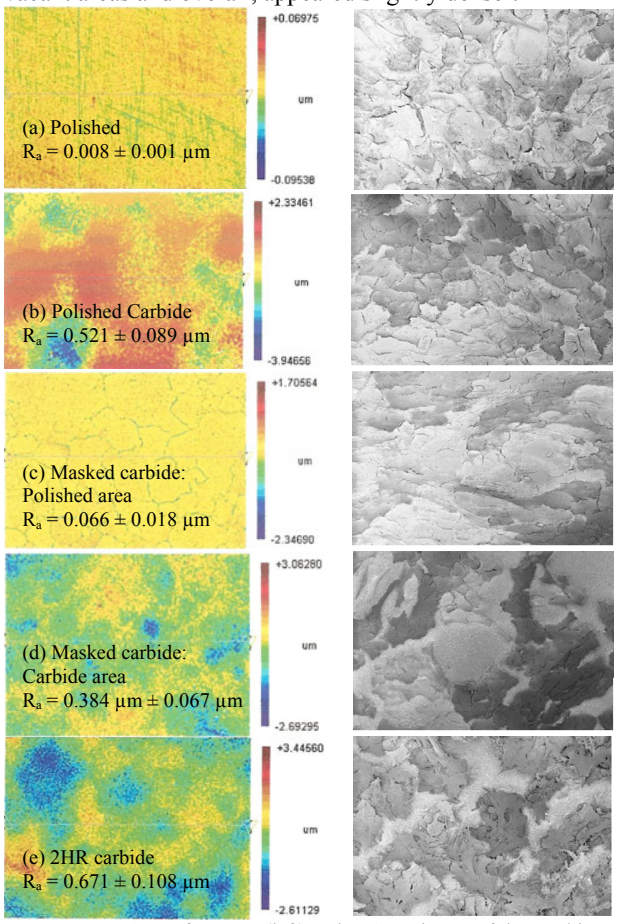

Figure 1. WLISP surface map (left) and FESEM image of the resulting cell coverage (right) for each respective CoCrMo-carbide surface type. Each image is approximately 0.342 x 0.257 mm.

Discussion/Conclusion: LIMB CoCrMo-carbide is not cytotoxic to MG63 cells. MG63 cells attached and remained viable on samples from each of the LIMB CoCrMo-carbide specimen surface types, as verified by FESEM imaging. The pattern of cell attachment on the native carbide test surface is influenced by the native carbide surface topography and coincided with the random pattern of surface waviness captured in WLISP surface images taken prior to cell culture. However, correlation to peaks and valleys could not be confirmed. Polishing of the 2HR specimen (Polished Carbide) changed the pattern of the cell attachment. The observation that LIMB CoCrMo-carbide supports osteoblast-like cell attachment and survival suggest its potential utility in clinical application.

References: 1.VanDamme, NS, et al. J of Matl Sci, 2005-16: 647– 654.

Acknowledgements: This research has been funded in part by the Arthritis Foundation.