Adhesion, growth and differentiation of human osteoblast-like MG 63 cells on metallic and polymeric materials developed for artificial joint replacements

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Recently, there is an increasing demand for artificial replacements of damaged tissues and organs. Therefore, the search for adequate artificial materials or innovation of materials currently used in the clinical practice is always reasonable. In this study, we investigated the adhesion, growth and osteogenic differentiation of human osteoblast-like cells of the line MG 63 in cultures on the following surface-modified metallic and polymeric materials, developed for construction of artificial hip joint replacements: Ti-6Al-4V alloy modified by plasma-spraying, polishing, plasma-spraying and coating with amorphous hydrogenated carbon (a-C:H) or polishing and coating with a-C:H; stainless steel AISI 316 LWM modified with plasma-spraying or polishing; non-modified or polished polyetheretherketon (PEEK) Optima, and non-modified or polished ultra-high molecular weight polyethylene (UHMWPE). Standard cell culture polystyrene dishes (TPP, Switzerland) served as a reference material.

On day 1 after seeding, the cells on all investigated materials adhered in lower numbers than on control polystyrene dishes (from 19,000±6,300 to 49,000±12,000 cells/cm^2 *vs*. 61,000±17,000 cells/cm^2), except Ti-6Al-4V treated by plasma-spraying and coating with a-C:H, where the cell number, as well as the size of the cell adhesion area, were comparable with the values obtained on the reference material. As revealed by an enzyme-linked immunosorbent assay (ELISA) the cells on plasma-sprayed and a-C:H-coated Ti-6Al-4V contained the highest concentration of integrin adhesion receptors with beta 1 chain (by 132% compared to the value on polystyrene), i.e., receptors for collagen, fibronectin and vitronectin, extracellular matrix molecules which are known to be spontaneously adsorbed on the materials from the serum supplement of the culture medium or deposited by the cells themselves.

On day 3 after seeding, also the cell number on Ti-6Al-4V treated by polishing and coating with a-C:H (126,000±4,700 cells/cm^2) equaled with the value on the control polystyrene (124,000±3,100 cells/cm^2). A relatively high cell number (121,000±4,500 cells/cm^2) was also obtained on polished stainless steel AISI 316 LWM. The cells on these samples contained the highest concentrations of integrins alpha v (i.e., receptors for vitronectin), vinculin (an integrin-associated protein) and osteocalcin (a calcium-binding extracellular matrix glycoprotein and important marker of osteogenic cell differentiation).

On day 8 after seeding, the cell numbers on almost all samples equaled with the values on control polystyrene, except the numbers on polished and relatively highly hydrophobic UHMWPE. On plasma-sprayed and a-C:H-coated Ti-6Al-4V, and also non-modified PEEK, the cell numbers even exceeded the values on polystyrene dishes. In addition, the cells on non-modified PEEK contained one of the highest concentrations of talin, another integrin-associated protein, and on polished PEEK, the highest concentration of osteopontin, another marker of osteogenic cell differentiation.

Therefore, it can be concluded that plasma-sprayed and a-C:H-coated Ti-6Al-4V, polished stainless steel AISI 316 LWM and PEEK seem to be the most appropriate materials for constructing bone-anchoring parts of joint prostheses, while polished UHMWPE can be used for creation of articular surfaces, where the cell adhesion and growth is not desirable.

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