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An attempt to correlate the characteristics of micro structured surfaces of Titanium implants and biological parameters of adhesive cells

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INTRODUCTION

One of the premises for biocompatibility studies of implant materials is the determination of morphological characteristics of their modified surfaces. Our investigations here were focussed on the question if the physical and chemical parameters used for the description of the surface of commercially pure titanium with different roughness can be utilised for the prediction of the cellular behaviour of osteoblastic cells.

MATERIALS & METHODS

The surface structure of cp-titanium samples was modified in a range of roughness average R_a from 0.19µm to 48.59µm by polishing (P), machining (NT), blasting with glass balls (2.7 bar) (GB), blasting with corundum particles (2,5 bar and 6 bar) (CB) and vacuum plasma spraying (VPS fine/medium/high). For the physical characterisation of the surface morphology the roughness average R_a and the fractal dimension D_F were used [1]. The R_a-values were obtained by surface profiling. The D_F-values were calculated by Digital Image Processing (DIP), Electrochemical Impedance Spectroscopy (EIS) and Linear Sweep Voltammetry (LSV) [2,3].
Cellular investigations were carried out in human primary osteoblasts [4] and MG-63 osteoblastic cells. Cells were cultured in DMEM with 10% fetal calf serum (FCS) and 1% gentamycin (Ratiopharm GmbH, Ulm, Germany) at 37°C and in a 5% CO_2 atmosphere. In general, cells were seeded with a density of $3x10^4$ cells/cm^2 onto the titanium materials and into control dishes. Following cellular parameters were investigated to evaluate the correlation to physico-chemical properties of the titanium: Adhesion, spreading (area), proliferation (cell cycle), integrin expression, length of integrin contacts, vinculin contacts in living cells (length) and their dynamics (GFP-vinculin), fibronectin synthesis, and mineralization.

RESULTS & DISCUSSION

The correlation between the biological results and the values of roughness parameters R_a and D_f was attempted with methods of PEARSON and of SPEARMAN.
Our trial showed not a trend to correlate between roughness parameters and length of integrin contacts, vinculin contacts in living cells (length) and their dynamics (GFP-vinculin) and spreading (area). But we could found a good correlation (coefficient of correlation r=0.8) between roughness parameters and fibronectin synthesis, mineralization and proliferation (cell cycle).
Interestingly, that the correlation between the fractal dimension D_F and the cell biological parameters is mostly better than with roughness average R_a.

CONCLUSIONS

The physical parameter fractal dimension D_F seems to be suitable for the correlation of morphological surface characteristics of biomaterials with cell biological properties and could be an indicator of later cell behaviour. We suggest that a more organized surface with pronounced D_F enhance cellular functions concerning adhesion.

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