Hydroxyapatite surface roughness: Complex modulation of the osteoclastogenesis of human precursor cells

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Article history:
Received 29 July 2011
Received in revised form 27 November 2011
Accepted 29 November 2011
Available online 6 December 2011

Keywords:
Hydroxyapatite surface roughness
Osteoclast differentiation
Peripheral blood mononuclear cells
Complex modulation

1. Introduction

Bone tissue has the ability to regenerate itself when subjected to partial damage [1–3]. Nevertheless, in the presence of a large loss of bone mass, caused by trauma or disease, the self-regenerative ability might be insufficient to promote a proper bone healing [1,2]. In such cases, bone regeneration can be achieved with a bioactive biomaterial, which modulates cellular activities in order to stimulate the self-regeneration ability of the tissue, allowing a progressive replacement of the biomaterial by new bone mass. Hydroxyapatite (HA), an inorganic calcium phosphate material, is one of the most widely used bone regenerative biomaterials, as its composition mimics the inorganic extracellular matrix of bone tissue [4,5].

The events taking place at the bone–material interface are determinant for the success of a bone regeneration process. A high, but coordinated, rate of bone remodelling is usually required, in order to replace the old bone and the biomaterial, repair fatigue damaged foci and maintain the structural integrity at the interface [6,7]. Therefore, as happens on a healthy bone, a successful biomaterial therapy requires a correct equilibrium between osteoblastic and osteoclastic activities [2]. These cells are not only responsible for bone metabolic activities, but are also key players on the regulation of the differentiation and activation of each other, through the production of either membrane-bound or soluble molecules [8]. The role of osteoblasts on osteoclastogenesis is well known [8] but the inverse relationship is less elucidated. In a recent study that detailed some reciprocal interactions occurring on a co-culture of osteoblastic and osteoclastic cells, we observed that osteoclastic cells have an important function on the regulation of osteogenesis [9]. In this context, both the osteoblastic and osteoclast activities and the reciprocal interactions between the two cell types are relevant at the bone–material interface.

The behaviour of osteoblastic and osteoclastic cells at the bone-implant surface is affected by the physical and chemical properties of the biomaterial surface [2,10,11]. The proper surface topography depends on the proposed application of the biomaterial [2]. The influence of the biomaterial surface on the osteoblastic behaviour has been reported in a variety of studies, and the increase in the surface roughness appears to favour osteoblast activity and material integration [11–16]. However, as referred above, osteoclast activity is also a key event at the bone–material interface [6,17]. Several studies were conducted with pure or chemically modified...