Tissue growth into three-dimensional composite scaffolds with controlled micro-features and nanotopographical surfaces

Abstract

Controlling topographic features at all length scales is of great importance for the interaction of cells with tissue regenerative materials. We utilized an indirect three-dimensional printing method to fabricate polymeric scaffolds with predefined and controlled external and internal architecture that had an interconnected structure with macro- (400–500 μm) and micro- (~25 μm) porosity. Polycaprolactone (PCL) was used as model system to study the kinetics of tissue growth within porous scaffolds. The surface of the scaffolds was decorated with TiO2 and bioactive glass (BG) nanoparticles to the better match to nanoarchitecture of extracellular matrix (ECM). Micrometric BG particles were also used to reveal the effect of particle size on the cell behavior. Observation of tissue growth and enzyme activity on two-dimensional (2D) films and threedimensional (3D) scaffolds showed effects of nanoparticle inclusion and of surface curvature on the cellular adhesion, proliferation, and kinetics of preosteoblastic cells (MC3T3-E1) tissue growth into the pore channels. It was found that the presence of nanoparticles in the substrate impaired cellular adhesion and proliferation in 3D structures. Evaluation of alkaline phosphate activity showed that the presence of the hard particles affects differentiation of the cells on 2D films. Notwithstanding, the effect of particles on cell differentiation was not as strong as that seen by the curvature of the substrate. We observed different effects of nanofeatures on 2D structures with those of 3D scaffolds, which influence the cell proliferation and differentiation for non-load-bearing applications in bone regenerative medicine.

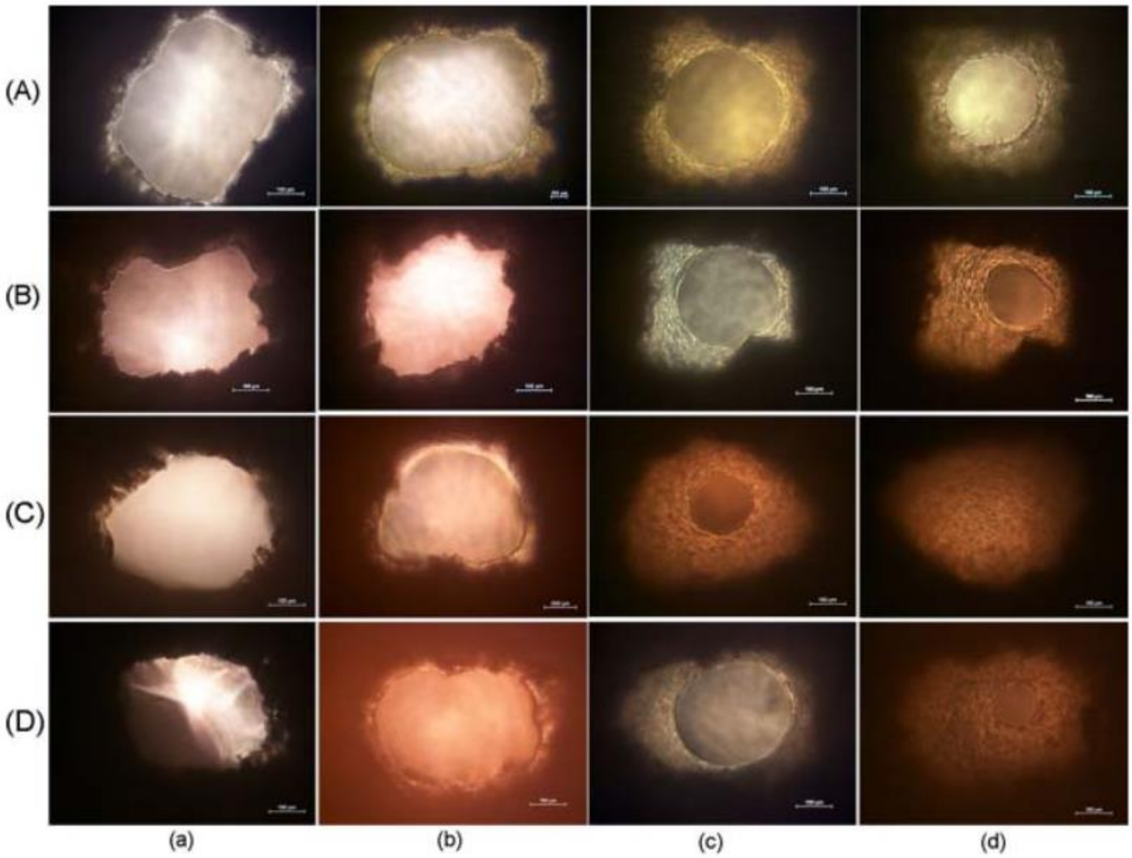

FIGURE 2. Phase-contrast micrographs showing ingrowth of cell in pore channels of (a) PCL, (b) PCL/TiO_2, (c) PCL/micro-BG, and (d) PCL/nano-BG scaffolds at different culture times of (a) 3, (b) 7, (c) 14, and (d) 28 days. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]