Interaction of osteoblast-like MG-63 cells with biodegradable polyurethane scaffolds for cancellous bone graft substitutes

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Statement of Purpose: Critical-size bone defects resulting from trauma, infection, and tumor resection do not heal spontaneously. Clinical procedures to heal such defects include autogenous cancellous bone graft, vascularized bone graft, bone segment transport, bone marrow aspirates, demineralized bone powder, platelet-rich plasma and growth factors. Allo- and heterografts are also often used, ignoring the potential problems associated with these materials. Another group of materials include ceramics based on hydroxyapatite, tricalcium phosphate and/or calcium carbonate, irrespective of their appreciated limitations. In consequence, numerous research activities are ongoing to develop other types of bone substitutes, which potentially may offer an alternative to autogenous cancellous bone graft, and/or extend ceramic bone graft portfolio. Microporous scaffolds from bioresorbable polymers, primarily polyhydroxyacids and polyurethanes[1-3] are among candidates for cancellous bone graft substitutes. The aim of this study was to evaluate the response of human osteoblast-like MG-63 cells in culture to 3-D microporous scaffolds from a biodegradable polyurethane-urea elastomer designed as a potential candidate for bone substitutes.

Methods: Polyurethane-urea with the number-average and weight-average molecular weights of 61500, 141810 Da and the polydispersity index of 2.30 was based on aliphatic isophorone diisocyanate, polyethylene adipate diol and 1,6 hexamethylene diamine as a chain extender. The original polymer and the scaffolds were characterized using NMR, FTIR-ATR, DSC, XPS, SIMS, Micro CT, water contact angle and SEM techniques. Mechanical tests were carried out in compression mode. This polymer was previously used for experimental cardiovascular implants [4]. Microporous caffolds were produced using a modified procedure described elsewhere [5]. Human osteoblast-like MG-63 cells (ATCC, Rockville, MD, USA) were used to investigate cell-scaffold interaction. Cells cultured without scaffolds were used as a control. Differentiation, growth and activity of cells on the scaffolds were estimated from the measurements of alkaline phosphatase and the total protein amount in the cell lysate at 7, 14, 21 and 28 days of culture. Cells proliferation was assessed from the WST-1 based colorimetric assay, and hematoxylin and eosin staining was applied for histological analysis of cells growing in the scaffolds.

Results: The polyurethane scaffold used in the study had interconnected pore structure with pore sizes in the range of 50 to 400 μm (Fig. 1). The pores in the walls separating individual pores were in the range of 1 to 40 μm. The cells attached to the scaffold produced extracellular matrix, grew into the pores and exhibited morphology typical of osteoblasts. The amount of DNA, alkaline phosphatase activity and the total proteins amount increased with time of culturing, reached the maximum at 2 and 3 weeks, and decreased slightly at 4 weeks.

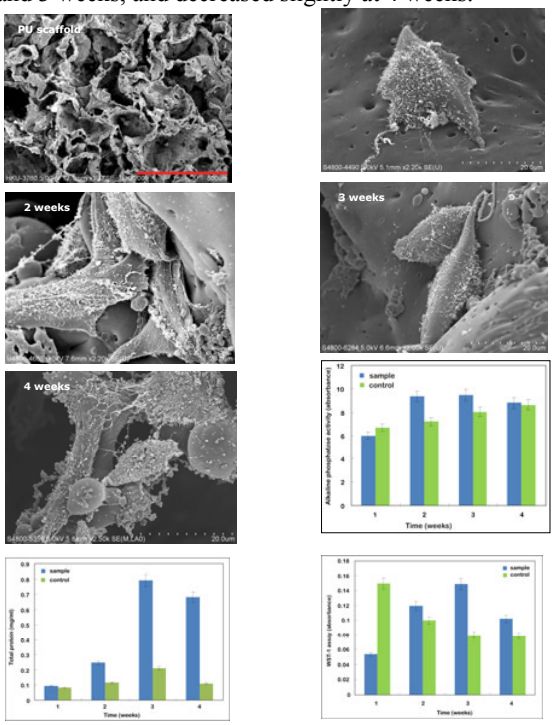

Fig. 1. SEM images of cells growing in the scaffolds, and alkaline phosphatase activity, total protein amount and cell proliferation at 1, 2, 3 and 4 weeks of culture.

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Conclusions: The biodegradable polyurethane-urea scaffold is conducive to attachment growth and proliferation of human osteoblast-like MG-63 cells, which are used experimentally to assess the *in vitro* ostoconductive potential of candidates for bone substitutes. The scaffold alone and preferably impregnated with autogenous marrow blood and/or platelet-rich plasma may potentially be used as a substitute for autogenous cancellous bone graft.

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