Abstract

In complicated skeletal injuries and trauma, the structural template needs to be introduced to aid the healing. The template or scaffold should have the ability to recruit the host stem cells and instruct them to regenerate the defect without any exogenous factors or cells. However, scaffolds should also be competent to form cell-scaffold construct with stem cells for critical defects. The present study is hypothesized that '*fabrication of nano/micro-architecture based multi-scalar 3D composite scaffold using a bio-inspired approach that mimic structural and compositional complexity of native bone'* may best suit for such purposes.

In the present study, two different phases were selected from biological waste materials. In one phase, an alternative method is proposed to create osteoinductive multiphasic CaP scaffolds through the printing of natural resourced materials such as eggshells and seashells. The conventional fabrication of CaP scaffold is a multi-step process. Here, predefined 3D multi-scalar porous scaffold was obtained in minimum processing steps with improved physico-mechanical properties, resorbability, and bone forming ability. The other phase was developed by microwave-assisted phosphorylation of chitosan, as a non-collagenous protein to reinforce the ceramic structure. Different bioinspired designs were prepared via combinatorial approaches using various fabrication techniques.

In vitro cell biological activity, protein adsorption kinetics, and degradation behaviour were evaluated to define the biochemical attributes. Detailed stem cell differentiation pattern and matrix deposition activities were assessed at phenotypically and transcription levels. The study established that the source of the scaffold could control the ossification pathway and offers site specific customization for bone defects healing.

The hybrid composite scaffold displayed amended structural strength and thick mineralized tissue deposition on stem cells seeding. The radiographic observation with histological studies evidenced controlled resorption with tissue regeneration at the critical-size bone defect. Overall, with different experimental outcomes, the thesis offers technological advancement for fabrication of 3D multiphasic calcium phosphate lattice as well as the synthesis of phosphorylated chitosan and their different combinations.

Based on the market analysis and cost calculation, it is evident that the bone graft substitutes fabricated in the present study using biological wastes are potentially viable for the intended application.

Keywords: Bone fracture, Ossification, Multiphasic Calcium Phosphate, Composites, Phosphorylation, 3D printing, Nanofibrous sheet.