A newly developed biodegradable injectable polymer-metallic hybrid material

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Statement of Purpose: Biodegradable injectable materials have attracted much interest to be used as bone filler as well as in tissue engineering of bone and cartilage since it can avoid an additional procedure of harvesting autologous bone[1]. Polycaprolactone (PCL) is one of the suitable candidates to be used as an injectable material since it has a relatively low melting point when compared with other polymers[2]. However, the low mechanical strength and intrinsic hydrophobic properties of this polymer may inhibit its use[3]. Hence, our group has recently fabricated an injectable biodegradable polymeric-metallic hybrid made of PCL and magnesium (Mg) to solve the problems. However, due to the rapid degradation of Mg, a surface treatment with the use of silane coupling agent (TMSPM) on the Mg beads was conducted. This study aims to investigate the mechanical and *in-vitro* properties of the newly developed hybrid.

Methods:

(a) Four types of the PCL-Mg hybrids were prepared by incorporating 0.1g and 0.6g 150μm Mg beads with and without silane treatment into 1g PCL, respectively.
(b) To test the mechanical properties of the hybrids, compression test was conducted with the use of the Material Testing System (MTS) machine.
(c) To study the biocompatibility of the PCL-Mg hybrids, green fluorescent protein osteoblasts (GFPOB) were cultured for 1 and 3 days. In addition, the cell viability of the hybrids was studied by conducting the 3 days MTT assay.

Results and Discussion: Figure 2 shows the result of the compression test. The compressive moduli were significantly increased from 233MPa of pure PCL to approximately 320MPa and 660MPa of 0.1g and 0.6g Mg hybrids, respectively. The results suggested that the mechanical properties of the pure PCL can be enhanced by increasing the amount of Mg beads incorporated and the values fall within that of cancellous bone (0.3-2.1GPa)[4]. However, no significant difference was found for the PCL-Mg hybrids with and without the silane treatment. Similar compressive moduli were found for the PCL-Mg hybrids with and without silane although it was reported that one of the functions of the silane treatment was to enhance the mechanical properties of the organic-inorganic composite[5].

GFP osteoblasts tolerated very well on the PCL-Mg hybrids except for the PCL-Mg hybrid with 0.6g Mg beads. This was probably due to the amount of Mg beads incorporated. In our previous *in-vitro* cytotoxicity test, the osteoblastic activity was affected by the Mg ion concentration. A higher concentration of Mg ion may inhibit the growth of osteoblasts. Hence, cells may die if the Mg ion concentration is too high. However, cells grew very well on the silane treated PCL-Mg hybrids especially on the hybrid with 0.6g Mg beads. 40% higher cell viability was found on the silane treated 0.6g PCL-Mg hybrid than the pure PCL (as shown in Figure 3). The result suggested that the silane treatment was able to slow down the degradation of Mg beads so as to activate the osteoblastic activity[6]. Therefore, the addition of metallic materials, Mg, would not only enhance the mechanical properties, but also the osteoblastic activity with the use of silane treatment.

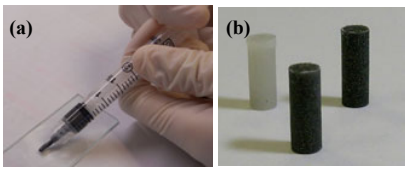

Figure 1. (a) The injectable PCL-Mg hybrids;
(b) The PCL and PCL-Mg rods for compression test.

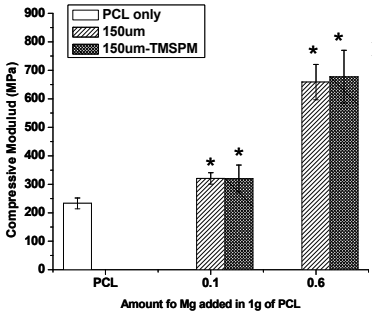

Figure 2. Compressive moduli of pure PCL and PCL-Mg hybrids. 1-fold and 3-fold higher of moduli were found on the PCL-Mg hybrids than pure PCL. (*p<0.05)

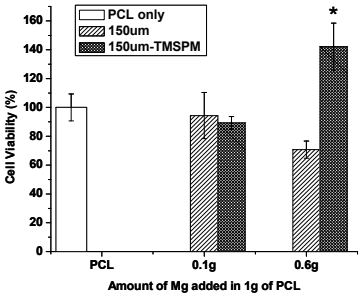

Figure 3. The cell viabilities of pure PCL and PCL-Mg hybrids. Similar cell viabilities were found for the 0.1g hybrids when compared to pure PCL. 40% higher cell viability was observed on the silane treated 0.6g PCL-Mg hybrid than pure PCL. (*p<0.05)

Conclusions: From the compression test and the *in-vitro* studies, the newly developed biodegradable injectable PCL-Mg hybrids are able to enhance both the mechanical properties and the osteoblastic activity of the PCL polymer so as to encourage bone formation. However, further studies including the osteogenic properties and *in-vivo* studies are still needed.

References: 1. Hou QP. J. Mater. Chem. 2004;14:1915-23; 2. Wei J. Biomaterials 2009;30:1080-88 ;3. Roether. Biomaterials 2002;23:3871-78; 4. Gibson LJ. J. Biomech. 2005;38:377-99; 5. Sabzi M. Prog. Org. Coat. 2009;65:222-28; 6. Zucchi F. Mater. Chem. Phys. 2008;110:263-68.

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