Porous titanium (Ti) scaffolds with various pore size controlled by camphene-based freeze casting for bone tissue engineering

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Introduction : Titanium (Ti) and its alloys have been widely used for dental and orthopedic implants, owing to their excellent chemical stability, mechanical properties and biocompatibility[1]. Recently, these materials in the form of porous structure have attracted increasing interest because they can provide not only a favorable environment for bone ingrowth, but also matching mechanical properties to those of the surrounding bones [2]. Among various manufacturing methods, freeze casting has recently demonstrated to be a useful method for the production of porous titanium. However, pore size of Ti scaffold fabricated by this method was about 100 μm [3]. For the biomedical porous scaffold, pore size should be increased further. Therefore, in this study, we fabricated Ti scaffolds with various pore sizes by controlling freeze casting procedure [4].

Methods : Titanium hydride (TiH_2)/camphene slurries with various TiH_2 contents (10, 15, and 20 vol.%) were prepared by ball-milling at 60 °C for 24 h[3]. Prepared slurries were poured into thin aluminum molds and kept at 42 °C for various periods of time (1~10 days), in order to allow an excessive growth of camphene dendrites. After de-molding, the green bodies were then freeze dried to remove the frozen camphene. Thereafter, the samples were heated up to 400 °C at a slow heating rate, up to 1300°C at a fast heating rate, and heat treated for 2 h [3]. The porous structures and chemical compositions of the samples were characterized using scanning electron microscopy in conjunction with energy dispersive spectroscopy (EDS). The crystalline phase of the samples was also characterized using X-ray diffraction. In order to evaluate their mechanical properties, their compressive stress–strain behaviors were monitored.

Results and Discussion: Fig 1. shows the fabricated Ti scaffolds with well-interconnected pores. It should be noted that the porous structure was uniform throughout the entire sample without any noticeable defects, such as cracking or large voids. As the casting time increased, the pores became larger, up to 300 μm, as shown in Fig 2. Compressive strength of the Ti scaffolds also increased with longer casting time. As the initial TiH_2 content increased, the pore sizes became smaller, as is often the case with the freeze casting method. The cellular responses to the Ti porous scaffolds were assessed using MC3T3 osteoblastic cell lines. The SEM morphologies of the cells cultured on Ti porous scaffolds are shown in Fig 3, which show the cells spread in intimate contact with the underlying Ti surface. Other *in-vitro* and *in-vivo* tests are under progress.

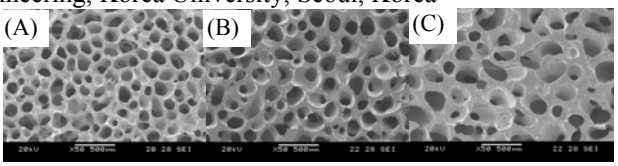

Fig 1. SEM micrographs of the porous Ti scaffolds(10 Vol.% of TiH_2 contents) produced with various casting times of (A) 1 day (B) 3 day (C) 7 day

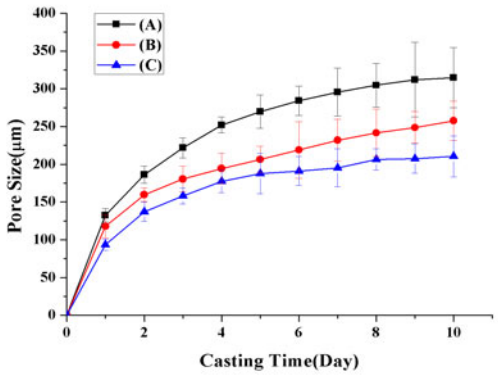

Fig 2. Pore sizes of the porous Ti scaffolds as a function of the casting time with various initial TiH_2 Vol.% (A) 10Vol.% (B) 15Vol.% (C) 20Vol.%

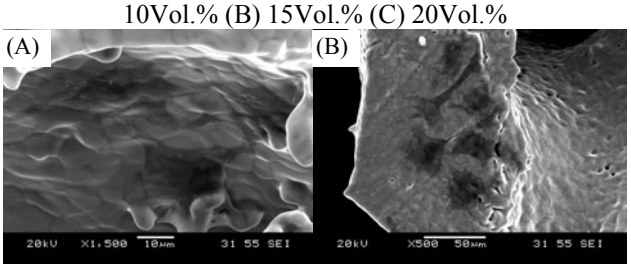

Fig 3. SEM image of the osteoblastic cells grown on the porous Ti scaffolds.

Conclusions: Highly porous Ti scaffolds with well-interconnected pores with various sizes were fabricated by controlling freeze casting procedure. As the casting time increased, pore size of Ti scaffold increased up to 300 μm, and their compressive strength increased at the same time. These results indicate that the camphene-based freeze casting technique is a promising method for producing porous Ti scaffolds for applications in bone tissue engineering.

References:

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4. St-Pierre JP. Biomaterials 2005; **26**; 7319-28