MgF_2 Coating on Porous Magnesium with High Strength and Corrosion Resistance for Biomedical Application

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Statement of Purpose: Porous scaffolds are attracting increasing interest in bone tissue engineering, because they provide a favorable environment for bone ingrowth and allow stable long-term fixation [1]. Magnesium (Mg) has been also recognized as a very promising biomaterial for bone implants because of its excellent mechanical properties and its favorable characteristics of being biodegradable and bioresorbable [2]. Therefore, Porous Mg scaffold has the potential to serve as a degradable scaffold for bone substitute applications.
However, previous porous Mg studies showed poor mechanical and corrosion properties due to low strength of Mg and high surface area of the porous structure. This study reports how porous Mg can be produced with high strength and corrosion resistance. The biological and mechanical properties of Mg scaffolds were examined for potential use as implant materials.
Methods: Mg (-100+200 mesh)/ Alumina (Al_2O_3, 1 vol%) composites was mixed uniformly with sodium chloride powder (NaCl, +80 mesh, 60vol.%) and spark plasma sintered (SPS) in low vacuum state [3]. Temperature was increased to 585 ℃ in 5 minutes and maintained for 2 hours. After sintering, NaCl was dissolved in 1M sodium hydroxide (NaOH) solution. For the MgF_2 coating process, the fabricated porous scaffolds were immersed in hydrofluoric acid (48 wt% in H_2O) at room temperature for 24 h [4]. The porous structures and morphology of the samples were characterized using micro-CT and SEM. Mechanical properties and corrosion behavior was evaluated by compression test and pH value, respectively. The *in vitro* biological properties were characterized by observing the MC3T3-E1 pre-osteoblast cell attachment.
Results: Figure 1 shows micro-CT image and SEM image of Mg and MgF_2 coated porous Mg/alumina composite with 60% porosity. This shows that Mg and alumina composite was sintered very well and MgF_2 coating layer was uniformly formed on the surface.
The compressive strength test was measured to evaluate the potential applications of the samples as a bone scaffold (Fig. 2). The compressive strength and stiffness increased by adding alumina. MgF_2 coating procedure did not decrease the compressive strength. The compressive strength of the MgF_2 coated porous Mg/alumina was as high as 8.6 MPa.
Because of the large surface areas of bare porous Mg, pH increases rapidly after immersion in SBF solution (Fig. 3 (A)). MgF_2 coating layer significantly suppressed the pH changes in the SBF compared to the bare porous Mg. Fig. 3 (B-C) is the SEM image of attached cell morphology on the specimen. The cells were well spread out and flattened on the MgF_2 coating than those on the bare porous Mg indicating that the coating layer increases biocompatibility.

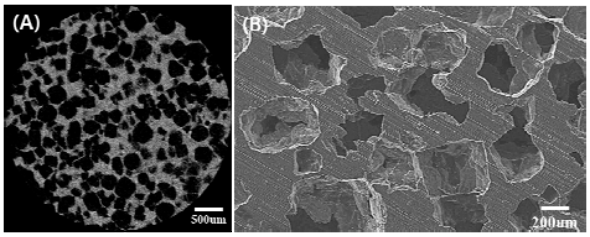

Fig 1. (A) Micro-CT image and (B) SEM image of MgF_2 coated porous Mg with 1vol% alumina

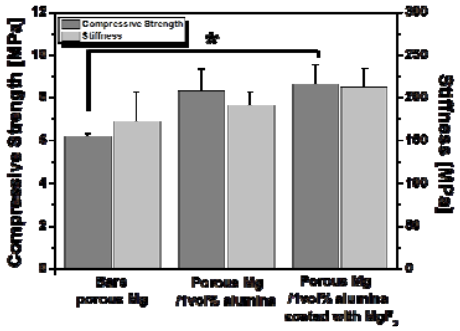

Fig 2. (A) Compressive strength and stiffness of various porous Mg specimens (*p < 0.05)

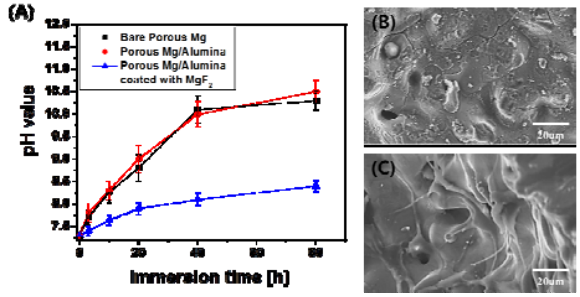

Fig 3. (A) pH value change after immersing various porous Mg specimens in SBF and cell attachment (after 24 h of culturing) of the MC3T3-E1 cells cultured on (B) bare porous Mg and MgF_2 coated porous Mg with 1vol% alumina

Conclusions: Porous Mg with enhanced mechanical and biological properties was fabricated. Significant increases in strength characteristics were observed by adding alumina powder. Also corrosion rate and cellular response of porous Mg was well controlled with MgF_2 coating. Our results show that Porous Mg is a potential alternative to existing load-bearing implant materials.

References:

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