Collagen self-assembly on orthopedic magnesium biomaterials surface and subsequent bone cell attachment

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Introduction:

Magnesium (Mg) biomaterials are a new generation of biodegradable materials and have promising potential for orthopedic applications. After implantation in bone tissues, these materials will directly interact with extracellular matrix (ECM) biomolecules and bone cells. Type I collagen, the major component of bone ECM, forms the architecture scaffold that provides physical support for bone cell attachment. Therefore, it is important to know how Mg materials affect collagen assembly. We studied the effects of collagen monomer concentration, pH, assembly time, and surface roughness of two Mg materials on collagen fibril formation and subsequent cell attachment.

Materials and Methods:

High Purity Mg extrusion rod and MgAlZn (AZ31) extrusion rod with diameter of 10 mm were cut into D10×1 mm disc and polished with SiC paper up to 1200 grit. All materials were supersonically cleaned in acetone and washed 3 times with ethanol followed by 30 minutes UV sterilization. For each experiment, at least 3 replicates were used. Collagen solution was allowed to assemble on different magnesium materials. Final collagen structure was imaged by scanning electron microscope. The amount of collagen absorbed on magnesium materials with different surface roughness was measured by Sirius Red kit. Mouse osteoblasts were used to test cell attachment on magnesium materials treated with collagen solution. Fluorescent staining was used to examine mouse osteoblast cell proliferation.

Results:

Results showed that formation of fibrils would not initiate until the monomer concentration reached a certain level depending on the type of Mg material. The thickness of collagen fibril increased with the increase of assembly time. The structure of collagen fibrils formed on semi-rough surfaces of Mg materials has a high similarity to that of native bone collagen. Materials with rough surface showed higher collagen adsorption but compromised bone cell attachment (Fig. 1). Interestingly, surface roughness and collagen structure did not affect cell growth on AZ31 for up to a week. Findings from this work provide some insightful information on Mg-tissue interaction at the interface and guidance for future surface modifications of Mg biomaterials.

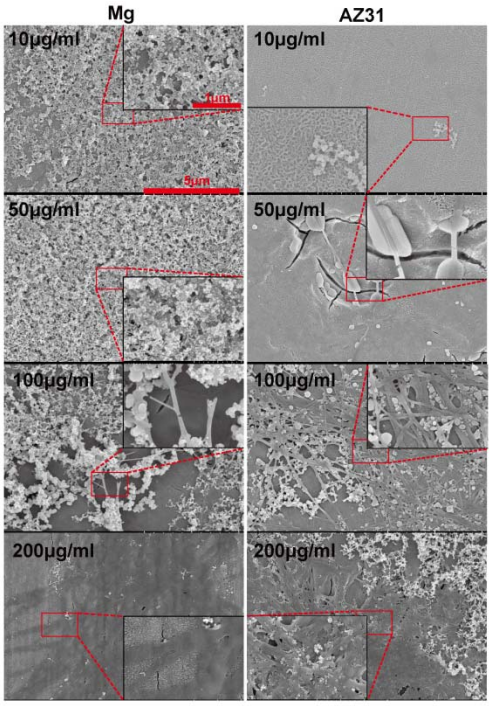

Fig.1 Collagen solution with different concentration assembly on Mg material surface.

Conclusions:

Collagen monomer can form different structures on Mg biomaterial depending on the initial collagen monomer concentration, pH in the solution, assembly time, electrolytes, and the material surface roughness. The pH can change the electrostatic properties of collagen and final collagen structure. With the increase of collagen assembly time, small fibrils merge with adjacent fibrils forming thicker fibers. Materials with rough surface show stronger collagen adsorption ability. Initial cell attachment on RS of materials decreased independent of the composition of materials. AZ31 surface roughness and collagen structure did not affect cell proliferation for up to 7 days. Materials with high degradation rate may not change collagen assembly structure but can affect osteoblast cell proliferation. In the future study, the combined effect of those factors such as pH, material surface roughness, assembly time and electrolytes on collagen assembly, mineralization and bone cell interaction should be addressed.