Effectiveness of Bioactive Ceramic-Based 3D Printing Scaffold Coating with BMP-2 in Induced Membrane Technique for Critical Sized Bone Defect of Rabbit

Jae-Woo Cho, MD; *Beom-Soo Kim, MD; Do-Hyun Yeo, MD; Wontae Cho; Eic Ju Lim; Seungyeob Sakong; Dong-Wan Kang; Imju Jeong, PhD; Jong-Keon Oh, MD, PhD*
Korea University Guro Hospital, Seoul, Korea, Republic of

Purpose: Although autogenous bone graft has been an optimal filling material in induced membrane technique, limited availability and complications of harvest site have led to the need for alternatives for optimal graft material. Our study is aimed to investigate the effect of 3-dimensional (3D) printing bioceramic scaffold coating with bone morphogenetic protein (BMP)-2 in critical sized metadiaphyseal bone defects in rabbit.

Methods: A 10-mm segmental bone defect was made at metadiaphyseal area of distal femur of 14 New Zealand White rabbits (average age, 4.5 months; weight, 3.0-3.5 kg). The defect was filled with polymethylmethacrylate (PMMA) cement and stabilized with 2.0-mm LCP T-plate. A week after first operation, CT scan was performed to design and print out defect specific bioceramic scaffold. After 4 weeks for maturation of membrane, the animals were randomized into Group 1 (3D printing bioceramic scaffold alone) and Group 2 (3D printing bioceramic scaffold coating with BMP-2) for implantation. Radiographs were performed every 4 weeks.
Euthanasia was performed at 8 weeks after grafting for visual, radiological, conventional CT, micro CT, biomechanical, and histological studies.

Results: Radiographic assessment showed that union rate of defect was significantly higher in Group 2 (7/7, 100%) than Group 1 (2/7, 29%). The average volume of newly formed callus measured in conventional CT was 472.55 mm3 in Group 1 and 1010.8 mm3 in Group 2. Total bone volume and tissue mineral density within scaffold, which were measured in micro CT, were greater in Group 2 than in Group 1. The average static and dynamic stiffness were significantly higher in Group 2. Histological examination revealed newly formed bone in both groups. Meanwhile, active new bone formation was found in Group 2.

Maturation of induced membrane for 4 weeks

Implantation of 3D printing bioceramic scaffold coating with BMP

Complete bony regeneration after 8 weeks

Conclusion: Bone regeneration in critical sized bone defect could be obtained with 3D printing bioceramic scaffold coating with BMP-2 in a small animal model. A 3D printing bioceramic scaffold coating with BMP-2 could be an alternative graft material in induced membrane technique for critical sized bone defect.