PCL Electrospun Sheet-Embedded Microporous PLGA Membrane For Effective Guided Bone Regeneration

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Statement of Purpose: Bone healing is one of the importance phenomena in clinical fields including oral, maxillofacial, orthopedic and plastic surgeries. In general, a major obstacle in bone healing involves the rapid appearance of fibrous connective tissue. The presence of fibrous connective tissue at the bone defect site prevents osteogenesis, resulting in the incomplete bone formation having low mechanical strength and cartilage-like tissue. To overcome this problem, guided bone regeneration (GBR) membranes made of some natural and synthetic polymers have been used to prevent connective tissue infiltration into the bone defect site. However, their fast absorption or non-absorption, brittleness, low mechanical stability and low permeability are still remained as limitations. In this study, we fabricated a novel GBR membrane with selective permeability, hydrophilicity and good mechanical stability by the immersion precipitation of poly(glycolic-co-lactic acid) (PLGA)/Pluronic F127 solution embedded with polycaprolactone (PCL)/Tween 80 electrospun sheet (called PCL/PLGA hybrid membrane). The morphology, mechanical (tensile and suturing) strengths and model nutrient permeability of the prepared membrane, and its bone regeneration behavior were investigated.

Methods: PCL was dissolved in a mixed solvent (MC/DMF, 85/15 (v/v); 10 wt%) and then Tween 80 (3 wt%) as a hydrophilic additive was added in the PCL solution. The solution was ejected from the capillary in a high voltage and thus the nano-fibrous sheet was formed on a collector plate. The prepared PCL electrospun sheet was placed on a mold and then PLGA/F127 (5 wt %) solution (in tetraglycol, 10 wt%) was filled into a mold, and then immersed into water for 1 hr at room temperature. The PCL/PLGA hybrid membrane was produced after washing the solidified PLGA/F127 mixture in excess water to remove residual tetraglycol and the following vacuum drying. The morphologies, mechanical (tensile and suturing) strengths and model nutrient (FITC-BSA) permeability were compared with those of PLGA/Pluronic F127 (5 wt %) membrane (called PLGA membrane), PCL/Tween 80 (3 wt%) electrospun sheet (called PCL electrospun sheet) and a commercialized GBR membrane, Bio-Gide®. Preliminary animal study using a rat model (skull bone defect; defect size, 8 mm) was also carried out to compare bone regeneration behaviors with the control (blank), PLGA membrane, PCL elelctrospun sheet and Bio-Gide®.

Results/Discussion: The prepared PCL/PLGA hybrid membrane had an asymmetrical pore structure: nano-size pores (~50 nm) on bottom side (which can prevent fibrous connective tissue infiltration but allow permeation of oxygen and nutrients) and micro-size pores (~40 μm) on top side (which can improve adhesiveness with bone). The PCL/PLGA hybrid membrane showed better tensile strength than or similar suturing strength to Bio-Gide® in wet condition, however, the PLGA membrane showed relative low mechanical strengths. FITC-BSA used as a model nutrient was continuously permeated through the membranes (PCL/PLGA hybrid membrane as well as PLGA membrane and PCL electrospun sheet), owing to their hydrophilicity. From the animal study, it was observed that the PLGA and PCL/PLGA hybrid membranes showed faster bone regeneration than the blank, PCL electrospun sheet and Bio-Gide®, probably owing to their selective permeability caused by unique morphology and osteoconductivity provided by several tens micro-size pores of bottom side. From the results of this study, it was recognized that the PCL/PLGA hybrid membrane can be a good candidate as a GBR membrane for the selective permeability and sufficient mechanical strengths as well as osteoconductivity.

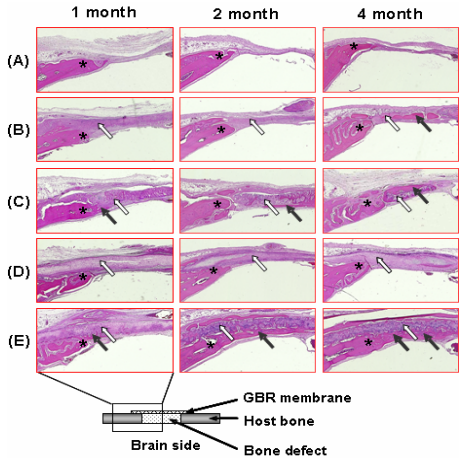

Figure.1. Histological sections of bone defect and surrounding cranial tissue covered without membrane (blank control) (A), covered with Bio-Gide® membrane (B), PLGA membrane (C), PCL electrospun sheet (D), and PCL/PLGA hybrid membrane with different periods. (*, host bone; white arrow, GBR membrane; black arrow, new bone; H&E staining, x 40).

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