Multilayer Fiber of PLA-PCL-PMMA-Collagen Composite as Meniscal Scaffold

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Abstract

With a prevalence of 66 cases per 100,000 individuals and an incidence rate of 12 to 14%, meniscal injuries represent the second most common knee pathology. By decreasing the tibiofemoral contact area by 40 to 50%, the standard treatment of arthroscopic partial meniscectomy elevates contact stress and exposes the joint to premature degeneration. This study aims to develop and evaluate a nano-microstructure scaffold utilizing a PLA, PCL, PMMA, and collagen composite, determining the optimal formulation for meniscal repair regarding mechanical, biological, and degradative properties. The composites were fabricated using fused filament fabrication and electrospinning. To construct a load-bearing macrostructure, PMMA rings were 3D printed at 250°C. Blends of PLA and collagen (PLA/collagen = 10/0, 9/1, 8/2, 7/3, 6/4 wt%) were electrospun with 10 wt% PCL in a chloroform and methanol (3:1) solvent, and 1 wt% PCL was then utilized to laminate the membranes onto the PMMA scaffold. The scaffolds were evaluated through in vitro enzymatic degradation (collagenase, 21 days), indirect MTT cytotoxicity utilizing human fibroblasts, SEM morphological analysis, uniaxial tensile testing, and FTIR spectroscopy. Demonstrating an ultimate tensile strength of 34.71 ± 4.10 MPa, a cell viability of 97.73 ± 15.11%, and a 17.78 ± 16.77% mass loss after 21 days, the PLA/collagen = 6/4 formulation shows a promising balance of strength, biocompatibility, and degradability. This offers a potential avenue for functional meniscal tissue regeneration and the prevention of post-meniscectomy osteoarthritis.

Keywords: *meniscal injury, scaffold, Poly(lactic acid), polycaprolactone, polymethyl methacrylate, collagen*