Meniscal Replacement in Canine Model Using Autologous Synovium-Derived Stem Cells-Seeded Scaffold

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Introduction: Various treatment modalities for meniscal defect including meniscal repair, meniscal allograft transplantation, and collagen meniscus implant have their own weaknesses. Tissue engineered scaffold using synthetic polymer can eliminate the problem of availability, sizing, and the transmission of infection. Addition of the autologous stem cells can have better regeneration of the meniscal tissue, but there are few studies about it. The purpose of this study was to evaluate meniscal tissue regeneration and chondroprotective effect by comparing 3 groups including meniscal scaffold groups seeded with or without autologous synovial cells and partial meniscectomy group in the knee joint of the dog during 12 months period.

Methods: Preparation of autologous synovium-derived stem cell and engineering meniscal scaffold: The polycaprolactone (PCL) scaffold with pores was fabricated as meniscal shape by melt-molding particulate-leaching method. Type I collagen was coated on the scaffold to enhance the cell attachment. Autologous synovium was harvested from the knee joint of a mongrel dog. Stromal cells were isolated and expanded for 4 weeks and passage 2 cells were used for seeding onto the scaffold with the density of $1 \times 10^7$ cells/ml. For labeling, PKH-26 was used as cell tracker. Surgical technique for the implantation of scaffold: Longitudinal skin incision and medial parapatellar capsulotomy was followed by exposure of medial meniscus of the dog. Medial meniscus was partially resected without damaging the articular cartilage, then scaffold was implanted onto the meniscal defect.

Group and parameters for evaluation: The dogs underwent different operations on both knees. All knees were divided into 3 groups: meniscal scaffold groups seeded with or without autologous synovial cells and partial meniscectomy group (cell-seeded group, cell-free group, meniscectomy group). They were sacrificed at 1, 3, 6, 12 months postoperatively and analyzed for resorption and integration of scaffold, cell and matrix evaluation, and cartilage protection effect by gross (Chang’s score, India Ink score) and microscopic findings (histologic stains, confocal microscopy, Mankin’s score).

Results: Degradable PCL scaffold began to integrate into residual native meniscal tissue from periphery of the scaffold. It was the most prominent at 12 months postoperatively (Figure 1). The degenerative change of the articular cartilage was the most severe in meniscectomy group at Chang’s score, India ink score and Mankin’s score (Figure 2). Seeded synovial cells were almost absorbed in the confocal microscopy at 12 months postoperatively (Figure 3).

Discussion: Autologous synovium-derived stem cell-seeded scaffold was better integrated into native meniscus and capsule in canine model, compared with non-seeded scaffold at gross finding. There was a tendency of better cartilage protective effect in scaffold implanted group than meniscectomy group. At 12 months after cell-scaffold implantation, labeled seeded cell and scaffold degraded over time but did not completely disappeared. In partial meniscal defect model in the canine knee joint, degradable PCL polymer scaffold seeded with autologous synovium-derived stem cell contributed to promoting regeneration of meniscal tissue.

Significance: In partial meniscal defect model in the canine knee joint, degradable PCL polymer scaffold seeded with autologous synovium-derived stem cell contributed to promoting regeneration of meniscal tissue.

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Figure 1. The maturation and integration of the scaffold was better in cell-seeded group compared with cell-free group and the degree of integration was the most obvious at 12 months.

Figure 2. Meniscectomy group had the most degenerative change of the cartilage grade by 6 and 12 months postoperatively.

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