

## HYDROGEL-BASED DELIVERY SYSTEM FOR REGENERATION OF ARTICULAR CARTILAGE DEFECTS

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Degeneration and traumatic damage of articular cartilage remain one of the most challenging problems in orthopedics due to the limited self-regenerative potential of hyaline cartilage. Current therapeutic approaches, including microfracture and autologous chondrocyte implantation demonstrate limited long-term efficacy and often lead to fibrocartilage formation instead of native hyaline cartilage.

We developed an injectable biocompatible fibrin hydrogel scaffold incorporating synovium-derived mesenchymal stem cells (SDMSCs) and controlled-release growth factors to enhance the regeneration of articular cartilage defects. The hydrogel provides a three-dimensional microenvironment that ensures cell viability, chondrogenic differentiation, and sustained delivery of growth factors (TGF- $\beta$ 1, BMP-4). Preclinical evaluation demonstrated that implantation of hydrogel with SDMSCs, TGF- $\beta$ 1 and BMP-4 significantly enhanced the regeneration of hyaline cartilage and the subchondral bone plate in osteochondral defects in rab-

bits within 12 weeks compared to hydrogels with SDMSCs or growth factors alone. In addition, histological analysis showed enhanced extracellular matrix deposition, expression of cartilage-specific markers (collagen type II), and superior biomechanical properties compared to control groups.

Early clinical evaluation in a pilot patient with grade 2 knee osteoarthritis confirmed safety and feasibility of the hydrogel-based therapy. At 6 months post-implantation, the patient demonstrated significant reduction in pain (VAS score), improvement in joint function (WOMAC index), and MRI evidence of significant cartilage regeneration. These encouraging findings indicate translational potential of this combined stem cell-hydrogel platform for minimally invasive regenerative treatment of osteoarthritis and focal cartilage defects.

**Key words:** articular cartilage regeneration, mesenchymal stem cells, hydrogel, growth factors, osteoarthritis