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Introduction: Degenerative disc disease (DDD) is one of the leading causes of chronic debilitating low back pain. DDD is characterized by changes in cellular characteristics resulting in loss of extracellular matrix(ECM) water holding capacity of the nucleus pulposus(NP). DDD can lead to translation of physiological loads from the anterior 2/3 of the spinal column to the posterior 1/3, resulting in increased stress on the facets and ligamentum flavum causing facet hypertrophy and canal stenosis. Novel stem cell regenerative therapies could restore the anterior column load via NP regeneration.

Methods: A hydrogel scaffold was created composed of self-assembling polyethylene glycol(PEG) functionalized with acrylate and thiol end groups. The scaffold was impregnated with NP cells differentiated from human umbilical cord mesenchymal stem cells(MSCs) or undifferentiated MSCs. Impregnated NP-scaffolds were implanted into an ex vivo rabbit model of DDD and the viability and function of NP cells was analyzed.

Results: The NP-scaffolds limited leakage and retained the cells in the NP region of the degenerated disc. Both the NP-scaffold and the overall disc environment promoted differentiation of the MSCs into cell types capable of producing ECM products, including sulfated glycoaminoglycans, at higher levels compared to undifferentiated MSCs injected into the intervertebral disc. NP-scaffold cells also expressed chrondrogenic markers, like SOX9, COL2, and ACAN, as well as NP markers FOXF1, K19, and vimentin at higher levels as determined by real-time polymerase chain reaction(PCR) and immunostaining.

Conclusion: This study demonstrated that a hydrogel scaffold impregnated with differentiated NP cells derived from human umbilical cord stem cells was much more effective at disc regeneration than undifferentiated MSCs alone. This method can lead to novel therapies for the treatment of DDD.