Injectable and RNA-releasing nanofibrous microcarriers for intervertebral disc regeneration

SUMMARY FOR THE GENERAL PUBLIC

Many people have experienced problems with lower back pain. A common cause of this pain is degeneration of the intervertebral discs (IVD), which are located between the vertebrae and help to give flexibility to the spine. The inner part of the IVD is called the nucleus pulposus (NP), a 'jelly-like' cushion between the spinal discs. Its role is to cushion the spine when we walk or jump.

IVD degeneration originates in the nucleus pulposus, which is made up of nucleus pulposus cells that produce a surrounding extracellular matrix (ECM) that holds water in the form of a natural hydrogel. The ECM creates an environment that supports the NP cells and helps to give the whole mechanical resilience. The IVD undergoes a progressive natural ageing process, potentially accelerated and enhanced by various traumatic or genetic factors. During NP degeneration, many processes lead to the destruction of the scaffolding in which the cells live. As a result, these processes lead to anatomical changes in the IVD and ultimately to forming of an NP protrusion that compresses the nerve root. This can cause unpleasant pain radiating from the buttock to the foot in cases where it is in the lumbar region that degenerative processes have occurred. This is also commonly referred to as a disc prolapse.

To illustrate the scale of the problem, imagine that around 80 per cent of the population will experience back pain at least once in their lifetime. The risk of the pain returning after the first episode is about 30 per cent. Lower back pain is also associated with repeated absences from work. It is one of the leading causes of severe disability and reduced quality of life. Treatment options for back pain include providing relief when symptoms worsen (administration of analgesics and anti-inflammatory drugs), and rest or physiotherapy is also recommended. Surgery is required when these measures in medication and rehabilitation are ineffective. In the worst cases, one of the most common surgical interventions is removing part of the nucleus pulposus or vertebral fusion.

Many research groups are working on novel treatments using native viable NP cells to help rebuild the ECM. Initial results from this work have been promising. Still, the therapeutic effects are lost in advanced stages of degeneration, where the cells are no longer present. In our group, we also contributed to developing injectable cell carriers that could be delivered to the NP minimally invasively. Furthermore, our solution allowed cells to be retained at the injection site without visible efflux during the procedure.

A continuation of this idea, presented in this project, aims to create a material that could transport non-coding miRNAs that would instruct cells to produce their natural scaffold. Our second goal is to create a material that would provide environmental cues to cells to promote their survival. At the same time, we want to create a biomaterial that perfectly mimics the hydrogel environment of cells in the nucleus pulposus. However, like all new biomaterials, it must undergo laboratory tests on cells and animals to be approved for human use.

We believe this work will result in a significant step forward in the field of IVD regeneration and open the door to the development of future minimally invasive therapies administered concurrently every few months rather than weekly, as is the case with potent painkillers.