Bioengineers are close to finding a cure for arthritis

Arthritis is a widespread health issue that has affected more than 350 million people worldwide and is a leading cause of disability. It occurs due to inflammation of one or more joints, such as the knees, knuckles, wrists or ankles. Normally, cartilage cushions protect these areas, but injury or ageing can wear them down. As the cartilage deteriorates, bones begin to rub against each other, making ordinary tasks like walking stressful. According to the Centers for Disease Control and Prevention (CDC), USA, approximately 58.5 million people in the US suffer from arthritis, costing them 303.5 billion dollars each year. There are over 100 distinct variants of arthritis that affect individuals of all ages, races, genders – though women are more likely to suffer than men – and people of all ages, from new-borns to the elderly. Contrary to common notion, arthritis is not a disease of the old. In fact, more than three out of every five persons with arthritis are under the age of 65 years. It is normally diagnosed through a series of physical examinations, blood tests and X-rays. The most prevalent type of knee pain is osteoarthritis (OA), which occurs when the protective cartilage that acts as a cushion at the ends of the bones breaks away over time. X-rays can be used to diagnose OA as well as abnormalities such as bone spurs, while blood tests detect antibodies that identify different types of arthritis.

While there are therapies available, there is no cure for arthritis. These therapies can only delay the damage rather than fix it. Procedures, like removing healthy cartilage from a patient or donor, are fraught with complications and dangers. As a result, regrowing healthy cartilage in the affected joint would be extremely beneficial. Some researchers have studied chemical growth agents to induce the body to rebuild the cartilage, while others have focused on a bioengineered scaffold to enhance tissue development. However, neither of these has succeeded, even when used in tandem, with the regrown cartilage disintegrating under the daily pressures of the joint. The global burden of arthritis is likely to have major effects in terms of healthcare expenditure and patient productivity today and over the next 30 years.

The recent findings by a group of scientists lend support to advancing a step further towards a permanent cure for arthritis. They have used a technique to mend joints using electrical implants, which may provide relief to millions of patients suffering from arthritis. The implants function by generating a current every time a person flexes his/her joints in order to regenerate the protective cartilage that covers the bone ends. Bioengineers at the University of Connecticut, USA have developed a biodegradable mesh implant, about half a millimetre thick, that produces small electrical impulses to repair arthritic joints in rabbits. During the study[1], they were able to successfully regenerate cartilage in rabbit knees without the use of potentially hazardous growth agents or stem cells. Importantly, the regenerated cartilage was mechanically resilient. They plan to test this implant in larger animals and humans in the near future. The implant incorporates a tissue scaffold comprising of poly-L lactic acid (PLLA) nanofibres, which are commonly used to repair surgical wounds that disintegrate after healing. When pressed, the scaffold generates a small burst of electric current known as piezoelectric current. Piezoelectricity is a natural phenomenon that occurs in certain solid materials such as crystals and ceramics, as well as biological matter such as bone, cartilage, collagen, DNA, and various proteins when mechanical stress is applied.

Walking generates a small electrical field that promotes cells to colonize the implant and develop into cartilage in this case, thus providing the joint with regular 'pressuring'. The researches had implanted the scaffold into the knees of wounded rabbits. Prior to the implant, the rabbits had also been trained to use a treadmill. After a month of recuperation, the rabbits were allowed to walk on a slow-moving treadmill for 20 min every day to exercise their legs and produce electric current. Two months later, the research team collected tissue specimens from the joints and graded them based on how intact and healthy they looked under a microscope. They found that the cartilage from these rabbits gave an average score of 15 out of 18 and stimulated the regrowth of new, mechanically strong cartilage, restoring the knee to its pre-injury state. In contrast, a group of rabbits given patches of a similar substance that did not produce electricity received a score of roughly 5 and had a hole in this protective layer that restricted recovery.

Thus a biodegradable piezoelectric PLLA scaffold, in conjunction with physical exercises, can be used to heal osteochondral problems. This scaffold could help create favourable surface charge for cartilage formation with regulated mechanical stimulation and hence function as a battery-free biodegradable stimulator. The results show the potential advantages of a biodegradable piezoelectric scaffold for cartilage tissue regeneration and treatment of OA. Although the findings are remarkable, researchers also caution that further testing has to be done on larger animals that are more similar to humans. They also mention that if the implant is used in humans, the substance used to produce it would dissolve after about two months – though it could be modified to last longer. The researchers now intend to monitor the treated animals for 1–2 years to guarantee the durability of the cartilage. They also intend to test the PLLA scaffolds in older animals, as arthritis is more common in the elderly. If the scaffolding aids in the healing of older animals, it indeed could be a milestone in bioengineering.

1. Liu, Y. *et al.*, *Sci. Transl. Med.*, 2022; doi:10.1126/scitranslmed.abi7282.

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