

# Spinning silk into next-generation eye and knee implants

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A scientist holds a silk-based knee implant in their fingers. Credit: © Orthox Ltd, 2022

For thousands of years, silk has been treasured for its qualities as a beautiful material for elegant garments. But scientists are harnessing the less obvious qualities of silk to develop versatile replacement parts for human eyes and knees.

The first word that comes to mind when you think of silk is probably not "strength," yet when it comes to toughness, pound-for-pound, smooth silk is stronger than steel. Few materials in the world match the flexible fiber produced by the silkworm.

"Silk has immense potential to be developed into materials that have the same functional properties as [healthy tissue](#), without any of the downsides of traditional implants," said Dr. Nick Skaer, chief executive of the U.K.-based biomedical company Orthox. "I'm confident that very soon—in the next few years—we'll be seeing some very large clinical needs being met by this versatile fiber."

There are good reasons to turn silk into [replacement parts](#) for the human body. This "super-fiber" is hard-wearing, highly elastic, is permeable to oxygen and water, biocompatible (is not rejected by the body when transplanted), stable and versatile (it can be engineered into a solid, a mesh or a gel). It is also able to block infection and supports the regeneration of new tissue.

## Weak at the knees

Dr. Skaer is part of [FibroFix Cartilage](#), a research team focused on transforming silk into substitute knee cartilage. Clinical trials launch in Hungary and the U.K. later this year with the hope that the [orthopedic implants](#) will soon be available to European patients.

When knee cartilage is damaged, and people develop osteoarthritis (OA) they may be referred for [knee replacement surgery](#) (arthroplasty). The painful condition causes bones to rub together in the joints and reduces mobility. It's also a widespread issue, with Europeans facing a 45% chance of developing OA. The risk increases with age and weight. It's estimated to cost European countries over €7.2 billion and rising to treat OA every year.

Knee-replacement surgery has reasonably good results but it's expensive, painful and recovery is long. It's also complex and not easily corrected if something goes wrong. Silk-based implants offer a tantalizing solution to these drawbacks.

FibroFix is made entirely of [silk protein](#) (known as fibroin) which has almost identical mechanical properties to real cartilage. "It's strong, it's slippery like cartilage and it deforms when you put pressure on it," said Dr. Skaer.

## Knee implants

Damaged cartilage is unable to repair itself easily and if left alone, a knee with cartilage damage will usually only get worse. The FibroFix researchers have developed a way to extract and purify fibroin and mold it into a shape suitable to use as an implant.

This is inserted into the knee in a dry, compressed state. It quickly fills with fluid from surrounding tissue which plumps it up to form a cushion-like barrier between bones.

Critically, the porous material also supports tissue regeneration. The silk protein implant provides a scaffold for bone and connective tissue to grow on so that even slow-repairing cartilage begins to regenerate.

The implant's benefits are two-fold. "Once the implant is locked in place, you get the function of your missing cartilage back straight away, and you also get new natural tissue growing over time," said Dr. Skaer.

Tests show the implant surgical procedure is quick, post-operative pain is minimal and recovery is straightforward. Dr. Skaer hopes for positive results in the [clinical trials](#). "We expect people to be on their feet soon after surgery and back to work fast, which will be a big win for

everyone," he said.

## Silky-looking

Live long enough and the day will come when you need glasses.

"Presbyopia affects precisely 100% of the population over the age of 45," said Susana Marcos, professor of research at Spain's Institute of Optics (CSIC) and the SILK-EYE principal investigator.

The team working on [SILK-EYE](#)—an EU-funded project headquartered in Madrid's Spanish National Research Council— have found a way to engineer the silk fibroin protein into a clear membrane that may one day be used to restore eyesight.

Presbyopia is the inability to focus on nearby objects. The condition is caused by hardening of the lens and gets progressively worse with age. The [standard treatment](#) here is to invest in a pair of glasses or contact lenses. There is no treatment to restore the lost functionality of the young lens.

The goal is to develop a silk-based implant that will replace the hardened lens in a simple surgical procedure. The new membrane will change shape as it's pulled by the eye muscles to focus on objects near and far.

"We're doing well with this project," said Prof. Marcos. "We've developed the silk membranes and fine-tuned the material so it has the properties we desire. It's transparent, elastic, easy to work with, has the right thickness and the right levels of permeability."

More work is required but the researchers have a clear target in mind—Prof. Marcos calls it the Holy Grail of ophthalmology—restoring older eyes to the capability of their 20-year-old selves. "It's on the mind of everyone in this field," she said.

Silk-based corneal implants may also be used to replace vision-correction laser surgery.

"Laser surgery (such as LASIK) removes a part of the corneal tissue, so your cornea becomes thinner," said Marcos. "But surgery using silk would be additive—we'd be adding the implant to what is already there, and therefore preserving tissue."

Globally, millions of people become blind as a result of corneal injury. It is a major public health challenge. The SILK-EYE researchers are working on affordable, implants and corneal bandages to address the problem.

The team has already had success fixing silk membranes onto the corneal surface using a light-enabled technique called photobonding—a technique that replaces the need for stitches.

There is a financial cost to silk lens and corneal [implant](#) treatments, but "We're hopeful that [silk](#) will be an affordable option for many people in Europe and around the world who are currently losing their sight from highly prevalent ocular conditions," said Prof. Marcos.

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