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Antibacterial coatings take the strain on orthopedic implants

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Newly developed 'smart' coatings for surgical orthopedic implants can monitor strain to provide early warning of implant failures while also killing infection-causing bacteria. The coatings integrate flexible sensors with a nanostructured antibacterial surface inspired by the wings of dragonflies and cicadas.

In a paper in *Science Advances*, a multidisciplinary team of researchers from the University of Illinois at Urbana-Champaign report that the coatings prevented infection in live mice and were able to map strain in commercial implants applied to sheep spines to warn of various implant or healing failures.

"This is a combination of bio-inspired nanomaterial design with flexible electronics to battle a complicated, long-term biomedical problem," said study leader Qing Cao, a professor of materials science and engineering.

Both infection and device failure are major problems with orthopedic implants, each affecting up to 10% of patients. Several approaches to fighting infection have been attempted, but all have severe limitations. Biofilms can still form on water-repelling surfaces, while coatings laden with antibiotic chemicals or drugs can run out in a span of months and have toxic effects on the surrounding tissue with little efficacy against drug-resistant strains of bacterial pathogens.

Taking inspiration from the naturally antibacterial wings of cicadas and dragonflies, the Illinois team created a thin foil patterned with nanoscale pillars like those found on the insects' wings. When a bacterial cell attempts to bind to the foil, the pillars puncture the cell wall, killing it.

"Using a mechanical approach to killing bacteria allowed us to bypass a lot of the problems with chemical approaches, while still giving us the flexibility needed to apply the coating to implant surfaces," said pathobiology professor Gee Lau, a co-author of the paper.

On the back side of the nanostructured foil, where it contacts the implant device, the researchers integrated arrays of highly sensitive, flexible electronic sensors to monitor strain. This could help



An artist's illustration of the novel smart coatings for orthopedic implants that have bacteria-killing nanopillars on one side and strain-mapping flexible electronics on the other. Image: Beckman ITG, University of Illinois.

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physicians to monitor the healing progress of individual patients, guide their rehabilitation to shorten the recovery time and minimize risks, and repair or replace devices before they hit the point of failure.

Yaszemski, Stuart B. Goodman, Amit Bandyopadhyay

The engineering group then teamed up with veterinary clinical medicine professor Annette McCoy to test their prototype devices. They implanted the foils in live mice and monitored them for any sign of infection, including when bacteria were introduced. They also applied the coatings to commercially available spinal implants and monitored strain on the implants in sheep spines under normal load for device-failure diagnosis. The coatings performed both functions well.

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The prototype electronics required wires, but the researchers next plan to develop wireless power and data communication interfaces for their coatings, a crucial step for clinical application. They are also working to develop large-scale production of the nanopillar-textured bacteria-killing foil.

“These types of antibacterial coatings have a lot of potential applications, and since ours uses a mechanical mechanism, it has potential for places where chemicals or heavy metal ions – as are used in commercial antimicrobial coatings now – would be detrimental,” Cao said.

*This story is adapted from material from the **University of Illinois at Urbana-Champaign**, with editorial changes made by Materials Today. The views expressed in this article do not necessarily represent those of Elsevier. [Link to original source.](#)*

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