Implantable biosensors

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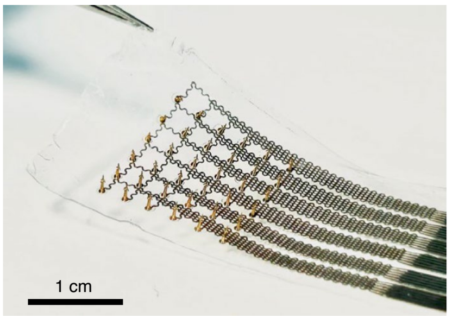
Bioresorbable microneedle array for biochemical monitoring of deep organ function



Continuous monitoring of organ function during and after surgery is critical for patient recovery, as complications such as organ injury, transplant rejection, or metabolic disorders develop gradually and are not detected early by standard vital signs, blood tests, or imaging. Biochemical markers provide more sensitive and specific signals of organ health, but devices capable of monitoring deep organs face challenges, including mechanical mismatch, limited long-term stability, and the need for surgical removal. Microneedles and bioresorbable electronics offer promising solutions, but existing approaches are limited by complex fabrication, poor tissue adhesion, limited biochemical sensing capability, and lack of controlled degradation. Now, writing in *Nature Biomedical Engineering*, Ouyang and colleagues present a bioresorbable microneedle-based system that achieves stable organ interfacing, multiparametric biochemical sensing, and electrically triggered self-destruction after use, enabling continuous and spatially resolved monitoring of organ function in vivo for at least one week.

The system integrates a bioresorbable microneedle implant, a wireless electronic module, and a bioresorbable electronic suture that connects the implant to external electronics. The microneedle array is fabricated using a programmable, photolithography-free process based on standard 3D printing, allowing precise control over its size, length, and shape. It conforms to organ surfaces, anchors with backward-facing barbs that improve tissue retention, and measures multiple biochemical markers including glucose, uric acid, lactic acid, electrolytes and oxygen, as well as electrophysiological signals. After monitoring is complete, applying an overpotential dissolves the metal electrodes and exposes the underlying bioresorbable materials without causing tissue damage.

A 3×3 microneedle array was implanted into rat organs to demonstrate multiparametric monitoring in vivo. In an acute kidney ischaemia model, the device tracked rapid drops and recovery in oxygen levels during periodic occlusion, while lactic acid and uric acid accumulated over time, indicating metabolic stress and possible organ injury. The array also mapped oxygen levels across different sites in the kidney. In a chronic model, the device monitored renal glucose for 7 days, showing strong correlation with blood glucose in healthy kidneys but impaired glucose response in ischaemic kidneys. When implanted in the intestine, the device monitored nutrient absorption and gut motility by measuring glucose, electrolyte levels, and muscle electrical activity.

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