Docket #: S25-116

A Mini-Patch Magnetic Insulin Pump for Enhanced Delivery Resolution and Accuracy

Researchers at Stanford University have developed a compact insulin pump for continuous subcutaneous insulin infusion (CSII) that addresses a core limitation of many commercial pumps: device size driven by piston-based mechanics. Most current insulin pumps rely on a motor coupled to screws, gears, and other transmission components to move a piston and dispense insulin. These mechanical subsystems, along with the integrated insulin reservoir, occupy a large fraction of the pump volume and constrain miniaturization, making pumps more noticeable and less comfortable for daily wear.

This novel mini-patch pump replaces the piston-and-transmission architecture with magnetic actuation. A magnetic soft actuator directly compresses the insulin chamber using a precisely controlled electromagnetic field. This design removes bulky force-transmission hardware and enables a substantially smaller form factor, reported as less than one-quarter the size of conventional piston-based pumps. The magnetic control scheme also supports high-resolution insulin delivery, with reported precision of 0.01 µL compared to 0.25 µL resolution reported for many piston-based designs. The high delivery resolution can support the use of high-concentration insulin formulations such as U500, reducing the required reservoir size and enabling further miniaturization. The pump performance can be tuned by adjusting the magnetic field waveform, amplitude, and duration, and the device has demonstrated strong repeatability and accuracy across single-pulse, basal, and bolus delivery modes.

Applications

- Mini-patch insulin pumps for continuous subcutaneous insulin infusion (CSII)

- High-precision basal insulin delivery for improved glycemic control
- Accurate micro-bolus dosing for meals, corrections, and automated dosing algorithms
- Wearable insulin delivery platforms optimized for discretion, comfort, and portability
- Insulin delivery systems designed to leverage high-concentration formulations to reduce reservoir size

Advantages

- Miniaturized pump architecture by eliminating bulky piston-driven components
- High-resolution insulin delivery
- Improved repeatability and accuracy across single-pulse, basal, and bolus delivery modes
- Tunable dosing performance by adjusting magnetic field properties
- Enables use of high-concentration insulins to reduce reservoir volume and support further device miniaturization
- Enhanced user experience through increased portability, discretion, and comfort during daily wear

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