An Ingestible, Self-Propelling, Electroceutical Device With Electroenterogram and Electrical Stimulation Capabilities for Noninvasive Management of Small Intestinal Dysmotility

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Small bowel dysmotility poses a significant clinical challenge, leading to digestive complications that impair quality of life. Existing diagnostics and treatments are often limited by side effects, variable efficacy, and lack of customization to individual motility patterns. To address these limitations, an ingestible electroceutical device was developed to enable real-time recording and stimulation of small intestinal electrophysiology. Once ingested, the device deploys flexible electrodes that conform to the intestinal mucosa, allowing continuous monitoring of patient-specific motility patterns. Using this real-time data, the device employs a feedback-based control loop to adjust electrical stimulation parameters, modulating motility based on the recorded intestinal activity. In vivo testing in an anesthetized porcine model demonstrated the device's ability to accurately record the characteristic slow-wave frequencies of the small intestine, with recorded dominant frequencies ranging from 0.143 to 0.161 Hz, perfectly aligning with the expected range of 0.133 to 0.2 Hz. During targeted stimulation in vivo, the device increased muscle contraction frequency by 100.014%, restoring it to the normal range, and enhanced contractile force by 138.373% as evidenced by intestinal electrophysiology. Functional motility significantly improved, with hydrogel bead transit increasing from a baseline of 5 cm to 18.4 cm with stimulation—a 3.68-fold enhancement. These findings highlight the device's potential as an adaptive, noninvasive therapeutic tool capable of personalized motility modulation. By dynamically tuning electrical stimulation to each patient's unique motility profile, this device offers a promising new approach to managing gastrointestinal dysmotility.

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