Multifunctional wireless gut-brain neurotechnology

Jae-Hwan Kim, Atharva Sahasrabudhe, Jeehwan Kim*

Massachusetts Institute of Technology

kjh00529@mit.edu, atharva@mit.edu, jeehwan@mit.edu

다기능 무선 장-뇌 신경기술 연구

Jae-Hwan Kim, Atharva Sahasrabudhe, Jeehwan Kim*
매사추세츠 공대

Abstract

We propose to develop multifunctional probes capable of wireless optogenetics, fluid delivery, photometric recording of cell signaling, and monitoring of motility and manometric signatures in the gut. Simultaneously, these tools will enable electrophysiological, photometric, and optogenetic interrogation of brain neurons to causally link gut physiology to brain function and behavior.

Ⅰ. Introduction

Gut-brain communication is essential in regulating physiological functions ranging from energy homeostasis to motility and barrier immunity. Dysregulation of gut-brain signaling is increasingly recognized as a key player in endocrine, immune, psychiatric, and metabolic disorders. Whereas studies of brain circuits have benefitted from decades of genetic tools and implantable probes for causal investigations, mechanistic understanding of gastrointestinal (GI) physiology is limited by a lack of tools that safely interface with the mobile and delicate gut. To overcome this barrier, we created neurotechnology that enables optogenetic and microfluidic interfaces with the intestinal lumen.[1] This technology permitted optogenetic control of feeding and reward behaviors by directly modulating enteroendocrine cells and vagal afferents in the gut in mice.

Ⅱ. Method

The multifunctional brain fibers were produced by thermal drawing from a macroscopic preform which was produced through computer numerical control machining of polycarbonate slabs. The preform assembly for soft, multifunctional gut fibers began with molding Styrene-Ethylene/Butylene-Styrene pellets into desired geometrical patterns in a computer numerical control-machined inverse aluminum mold under vacuum. A flexible printed circuit board served as a substrate, with electrically defined circuit interconnects and the fiber pads for microscale light-emitting devices (μ LEDs), photometers, microfluidics, flow and pressure sensors.

Ⅲ. Conclusion

Our probes will be produced through a combination of scalable methods, fiber drawing and laser micropatterning, and will be equipped with an array of embedded micro-devices. To achieve wireless control of device functions during behavior, we will collaboratively develop a flexible, implantable circuit and software for bidirectional communication with implanted probes via standard Bluetooth protocol. Designed with dissemination in mind, our tools will be evaluated across two institutions. Although initially designed to probe gut and brain physiology, our platform will also lay the foundation for applications in other peripheral organs, such as the kidney, liver, or pancreas. Given its potential broad impact, our neurotechnology will be disseminated through the proposed “Body-Brain Neurotechnology Core.”

ACKNOWLEDGMENT

This work was supported by the National Research Foundation of Korea. (NRF) funded by the Ministry of Science and ICT (RS-2024-00460364)

REFERENCES

[1] Sahasrabudhe, A. et al. "Multifunctional microelectronic fibers enable wireless modulation of gut and brain neural circuits." Nature Biotechnology 2023 13, 1- 13 (2023).