A novel humanoid-robot simulator for colonoscopy

Colorectal cancer is the cancer with the third-highest incidence worldwide [1]. Colonoscopy is a useful imaging modality that has a high sensitivity and can reduce mortality from colorectal cancer [2]. Although diminutive adenomas pose a lower risk of malignancy than larger ones, an increase in adenoma detection rates may contribute to decreasing the risk of colorectal cancer [3]. However, operator proficiency has been a difficult hurdle to overcome. Basic insertion skills are required to perform a standardized colonoscopy. As observing the whole lumen with as few blind spots as possible is a basic prerequisite for qualified endoscopic diagnosis, subjective factors or limited levels of ability in the endoscopists may lead to missed lesions. Endoscopic training is expensive both in time and costs, and there is also a lack of realistic simulators for trainees. For these reasons, we developed a humanoid-robot simulator, called a “mikoto,” that allows endoscopists to insert the colonoscope in a way that feels comparable to performing a colonoscopy in the human body (▶ Fig. 1). The three-dimensional colon model, the data for which was prepared using CT images of the human colon, is made of a silicon resin that is thinner and more flexible than conventional models (▶ Fig. 2, ▶ Fig. 3, ▶ Fig. 4, ▶ Fig. 5). Insertion of the colonoscope can be scored by evalu-
ating the pressure of the colonoscope on the colon, the distensibility of the colon, and the duration of the procedure (▶Fig. 2). The mikoto has additional functions, such as the ability to change the body position; the capability to adjust colonoscope insertion for different levels of difficulty, exert abdominal compression, and reposition the diaphragm as if through deep inspiration; and the ability to provide alerts when the colon forms a loop (▶Video 1). The mikoto outperforms other self-training methods for trainees to learn how to insert the colonoscope successfully. Additionally, it is less invasive, and the performance scoring system provides more objective feedback than examinees might obtain in an actual clinical setting.

Competing interests
Masashi Fujii was employed on an advisor of MICOTO Technology Inc. The other authors declare that they have no conflict of interest.

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