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Personalized, 3D printed shields developed to protect patients during radiation therapy

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Radiation therapy is used as a treatment for more than half of all cancer patients and can be highly effective at shrinking tumors and killing cancer cells. But radiation treatment can also damage healthy tissue, including tissue in the mouth and gastrointestinal tract. This tissue injury can lead to oral mucositis, esophagitis, and proctitis—painful and sometimes debilitating tissue damage. It's estimated that these injuries occur in over 200,000 patients in the U.S. each year. In a new paper published in *Advanced Science*, investigators from Brigham and Women's Hospital, Dana-Farber Cancer Institute, Massachusetts General Hospital and MIT describe efforts to develop a new personalized, 3D-printed device intended to shield patients who are undergoing radiation therapy and prevent radiation-induced toxicity. The work to date has been conducted in preclinical models and uses simulations to predict effects in humans, laying groundwork for clinical trials for patients.

"When we treat patients with radiation, we do our best to minimize the area of healthy tissue that receives radiation and break up treatment into small doses, but it's a fine balance. We want to administer the most dose we can to shrink the tumor without causing damage to healthy tissue," said lead author James Byrne, MD, Ph.D., a postdoctoral researcher in the Traverso lab at the Brigham and MIT and a senior resident physician in Radiation Oncology at Brigham, MGH, and Dana-Farber Cancer Institute. "Our goal through this project was to find an innovative solution that could offer personalized protection for patients."

Byrne collaborated with a multi-disciplinary team on the work, including

experts in radiation oncology, physicists, mechanical engineers, and gastroenterologists.

"It's not uncommon for gastroenterologists to be called in to consult on a case to support a patient who is experiencing side effects of radiation in the esophagus, small intestine or anywhere else in the gastrointestinal tract," said corresponding author C. Giovanni Traverso, MB, BChir, Ph.D., a gastroenterologist and biomedical engineer in the Division of Gastroenterology at the Brigham and MIT. "A couple of years ago, James and I began brainstorming—what if we could develop a shield that could help protect a significant portion of normal tissue in the radiation field?"

Byrne and colleagues tested a broad range of materials—both solid and liquid—from which to construct the radioprotective shields. The team focused on high atomic number (Z) materials, which can prevent gamma and X-rays from passing through, and other materials to reduce radiation backscatter. Using CT scans from patients, the team created designs unique to individual patients and used 3D-printing to generate them. They tested their shields in rats and pigs. They found that the shields could protect healthy tissue in the mouth and rectum in rats with good feasibility and reproducibility of placement in pigs. In simulations of human patients, the team estimated that the device could reduce radiation to areas in the mouth by 30 percent for head and neck cancer patients, and in the gastrointestinal tract by 15 percent in prostate cancer patients, without reducing radiation dose to the tumor.

The authors note that this work is an initial proof-of-concept study and additional investigations will be needed to translate the devices for use in the clinic. However, their results so far suggest that personalized shields could someday help reduce the risk of radiation toxicity.

"Our results support the feasibility of personalized devices for reducing

the side effects of radiation therapy," said Byrne. "This personalized approach could be applicable to a variety of cancers and holds the potential to reduce the burden of radiation injury and toxicity for our patients."

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