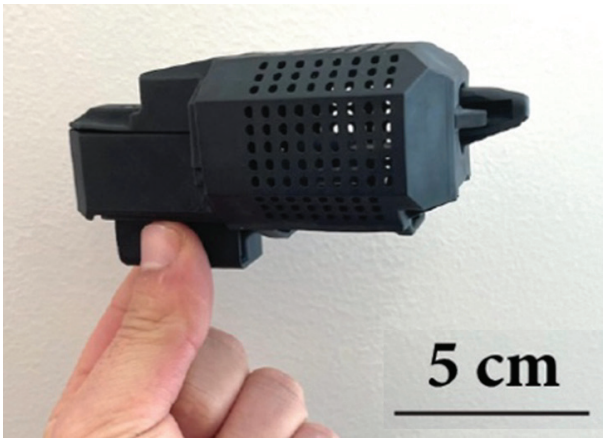

Figure 1: The microscope in a compact 3D printed housing.

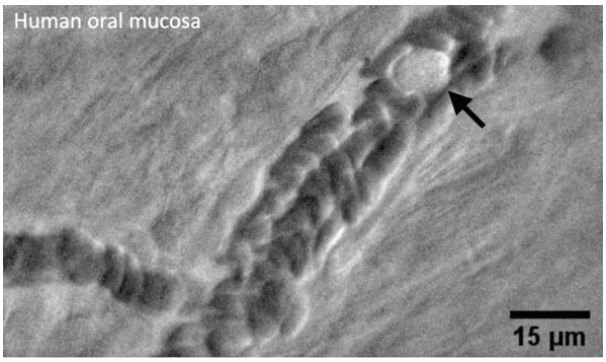

Figure 2: A still frame from a video of the microcirculation in the human oral mucosa. Arrow points to a white blood cell.

Counting White Blood Cells Without Drawing Blood

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Despite tremendous advances in imaging technologies such as MR, CT and PET, a method for noninvasive monitoring of the immune system does not exist. White blood cell (WBC) count, a key metric for assessing a patient's immune status, requires drawing blood for laboratory analysis. Drawing blood poses inherent risks for secondary infection and anemia in vulnerable patient populations, such as infants, critically ill patients, and oncology patients. Additionally, laboratory analysis can be slow and requires specialized equipment, expertise, and infrastructure that are not always available in resource-poor settings. To address these limitations, we have developed a compact microscope that enables real-time imaging of circulating blood cells in the microvasculature of the human oral mucosa, capturing videos of fast flowing cells in the blood stream. In addition, we have developed an analytic pipeline to detect and enumerate WBCs from the videos. We tested our device on a cohort of healthy volunteers and validated our image-based WBC count with the clinical standard from blood draw. We benchmarked the time it took to obtain a stable WBC count from a single microvessel (about 3 minutes). We found that the WBCs are not uniformly distributed among individual microvessels, and it is necessary to image multiple microvessels in order to obtain a reliable WBC count. Our next generation device will capture videos of multiple vessels simultaneously to improve measurement accuracy.

Beyond cell counting, our imaging technology enables direct visualization of WBC motion along the vascular wall. Immune cell migration is essential for immune function. Recruitment of WBCs into tissue starts with their tethering, rolling, and adhesion on the endothelium lining the blood vessel walls. Known as leukocyte-endothelial interaction (LEI), it is a hallmark of inflammation. Our instrument provides high-resolution videos of LEI in real time, and we are developing machine learning tools for diagnosing systemic inflammation such as sepsis by automatic detection and tracking of leukocyte motion on the endothelial surfaces.

We are launching a startup to produce a clinically viable product for noninvasive blood cell analysis and welcome discussions with interested parties.