Using pain-free microneedle skin patches to sample tissue-residing leukocytes

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Motivations and Background
- Blood draws are commonly used to interrogate an individual’s health, but their invasive nature makes them undesirable for some. They also require a trained professional and the infrastructure to dispose of the created biowaste, qualities that are not accessible throughout the world.
- Skin interstitial fluid (ISF) contains many of the same metabolites found in the blood, as well as a large and unique leukocyte population absent in the blood, which can give insight into autoimmune skin diseases, vaccine responses, and organ transplants.
- Current methods of sampling ISF are invasive, cause discomfort, and lead to scarring. Thus, we have fabricated microneedle (MN) skin patches that can sample ISF in a pain-free manner.

Methods

Fabrication of microneedles
- MN backbone is fabricated by melt molding poly-l-lactide (PLLA).
- The polymer is plasma activated to increase its hydrophilicity.
- An aqueous alginate solution is added to the PLLA.
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- To form the hydrogel, the alginate is crosslinked with calcium chloride, allowed to dry, and stored in a desiccator.

Vaccination and sampling
- Ovalbumin (10 µg/mouse) Lipo-CpG (1.24 nmol/mouse)
- Current methods of sampling ISF are invasive, cause discomfort, and lead to scarring. Thus, we have fabricated microneedle (MN) skin patches that can sample ISF in a pain-free manner.

Results

Sampling Capacity
- Our MN patches as less than an inch in length, allowing for comfortable long-term sampling.
- Since our MNs are ~600 µm in height, they avoid nerves in the skin and prevent pain.

Cytokine and chemokine panel
- MNs are coated with a hydrogel layer that swells upon skin insertion.
- SEM image shows cells trapped in the hydrogel, which will later be analyzed (see methods).

Conclusion and Perspective
- Our sampling MN patches collected a range of immune cells, including ovalbumin-specific T cells (denoted by the CD8⁺ tetramer marker) and innate immune cells (denoted by the CD11b⁺ marker) found in ISF.
- Monitoring of the immune system by these MN patches could be used to predict immune flares associated with autoimmune skin diseases like lupus and psoriasis, allowing for quicker treatment.
- These MNs can potentially be used as a diagnostic tool for tuberculosis and cancer by sampling biomarkers found in ISF. The figure below shows the sampling of miRNA since some miRNA sequences are promising cancer biomarkers.

References