Single-cell leukocyte mechanics: force generation and rheology

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Leukocytes are very soft cells that perform many diverse functions: they adhere, crawl, transmigrate, kill, phagocytose or interact with other cells. During their activation, leukocytes both generate mechanical forces and change their viscoelastic properties (i.e. they stiffen/soften, get more or less viscous). We have developed micropipette-based setups to quantify single-leukocyte mechanical properties and monitor them over time while a leukocyte gets activated by a relevant stimulus.

We use this approach in diverse contexts involving leukocytes: activation of T lymphocytes, phagocytosis of a target by a neutrophil, or transmigration of a lymphoblast across an endothelial monolayer. We measure forces generated by T lymphocytes[1-3] and perform microrheology experiments with a profile microindentation setup[2,4,5] (Figure 1), These mechanical measurements shed a new light on how cell mechanical properties evolve over a short period of time (seconds), how they adapt to the stiffness of their environment, and how intracellular signaling is involved.

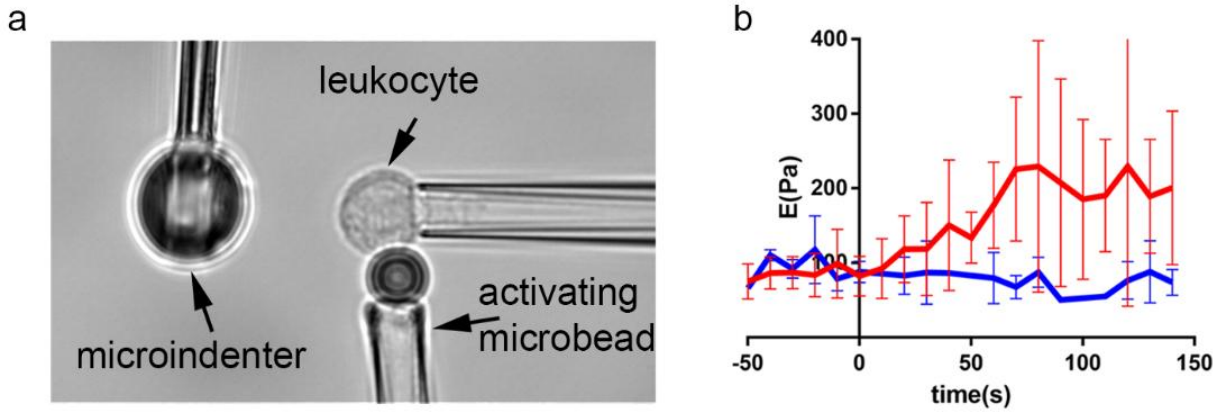

Figure 1. (a) Microindentation setup coupled to an auxiliary micropipette bringing an antibody-covered microbead in contact with a leukocyte help by a micropipette. Cell viscoelastic properties of the leukocyte can be monitored over time during cell activation. (b) Time evolution of the leukocyte Young's modulus its activation (red curve). Cell-bead contact occurs at time t=0. The curve in blue corresponds to a non-activating bead.

1. Basu, R.*, Whitlock, B.M.*, Husson, J.*, Le Floc'h, A., Jin, W., Dotiwala, F., Giannone, G., Hivroz, C., Lieberman, J., Kam, L.C. & Huse, M. Cytotoxic T Cells Use Mechanical Force to Potentiate Target Cell Killing. ***Cell*** **165**(1):100–110 (2016).

2. A. Sawicka, A. Babataheri, S. Dogniaux, A. I. Barakat, D. Gonzalez-Rodriguez, C. Hivroz, and J. Husson. Micropipette Force Probe to quantify single-cell force generation: application to T cell activation. ***Molecular Biology of the Cell***, 2017 (in press).

3. Husson, J., Chemin, K., Bohineust, A., Hivroz, C. & Henry, N. Force Generation upon T Cell Receptor Engagement. ***PLoS One*** **6**(5):e19680 (2011).

4. Guillou, L., Babataheri, A., Puech, P.-H., Barakat, A.I. & Husson, J. Dynamic monitoring of cell mechanical properties using profile microindentation. ***Scientific Reports*** **6**:21529 (2016).

5. Guillou, L., Babataheri, A., Saitakis, M., Bohineust, A., Dogniaux, S., Hivroz, C., Barakat, A.I. & Husson, J. T lymphocyte passive deformation is controlled by unfolding of membrane surface reservoirs. ***Molecular Biology of the Cell*** **27**(22): 3574-3582. (2016, journal cover).