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Microrheologycal Tools for Pericellular Coat Viscosity Measurement

Alex MARKI [1], Axel PRIES [1, 2, *]

* Corresponding author: Tel.: +49 30 450 528 501; Email: axel.pries@charite.de
1 Institute of Physiology, Charité Medicine University, Berlin, Germany
2 Center of Cardiovascular Research, Charité Medicine University, Berlin, Germany

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Eukaryotic cells present different proteins, glycoproteins and proteoglycans on their extracellular surface and these moieties form a gel-like pericellular coat (PC) which is also called as glycocalyx or surface layer. The PC influences chemically and mechanically the interaction between the cell and its environment depending on the cell type, e.g. PC regulates the mechanical load falling on chondrocytes and the PC of endothelial cells regulates the interaction between the endothelial cells and leukocytes. Characterization of the PC's mechanical properties (stiffness, viscosity) especially in vivo is challenging and requires novel methodologies.

Here we report on two approaches, the single particle tracking and the use of molecular rotors. The first approach relies on detecting the thermal vibration of fluorescent tracer particles moving inside the PC. According to the Stokes-Einstein law, the mean square displacement of a particle's thermal vibration is inversely related to the viscosity of the embedding medium. This allows local viscosity calculation in a sample with known temperature via tracking the displacement of a tracer particle of known diameter. For this approach the applied tracer particles have to be small enough to invade the PC but large or bright enough to allow dynamic imaging. Surface modification (charge, binding affinity) of the tracer particle can influence the interaction between the particle and the PC allows testing the chemical properties of the PC.

Another potential novel approach is provided by "molecular rotor" fluorophores (MR). Due to their molecular structure, MR's quantum yield is directly related to the viscosity of the embedding medium. MRs are small molecules and therefore they can invade the PC rapidly. However in-homogeneous local concentration of the dye can bias the measurement. This can be addressed by using ratiometric MRs, which combine a viscosity sensitive and a viscosity insensitive fluorescent domain.

The described tools allow microrheologycal assessment of gel-like layers of biological or non-biological origin. Application of molecular rotors is preferable for layers thinner than 100 nm and it offers visualization of local viscosity gradients. On the other hand the single particle tracking approach offers a localized measurement with about 10 nm 3D resolution in a standard wide-field fluorescent microscopy.