Numerical simulation of platelets adhesion on structured artificial surfaces.

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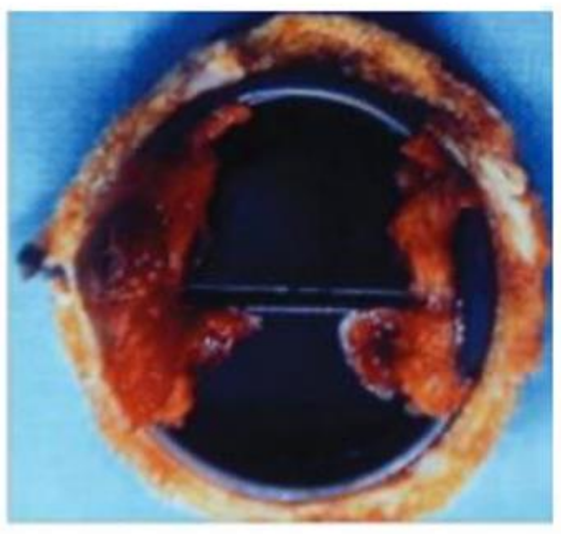
Introduction

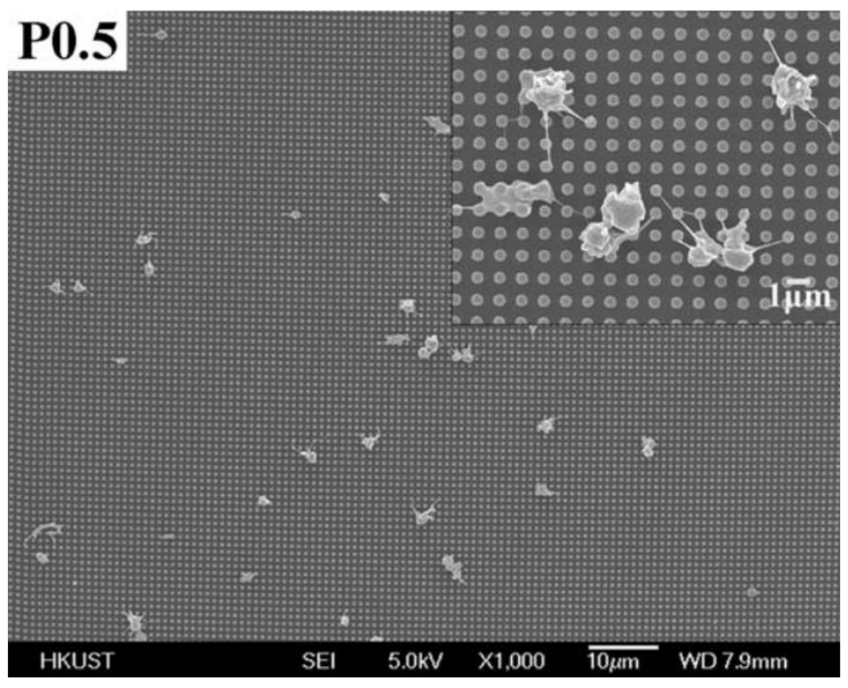
Context

The **hemocompatibility** of blood contacting medical devices remains a key challenge to their development.



In-vitro observation

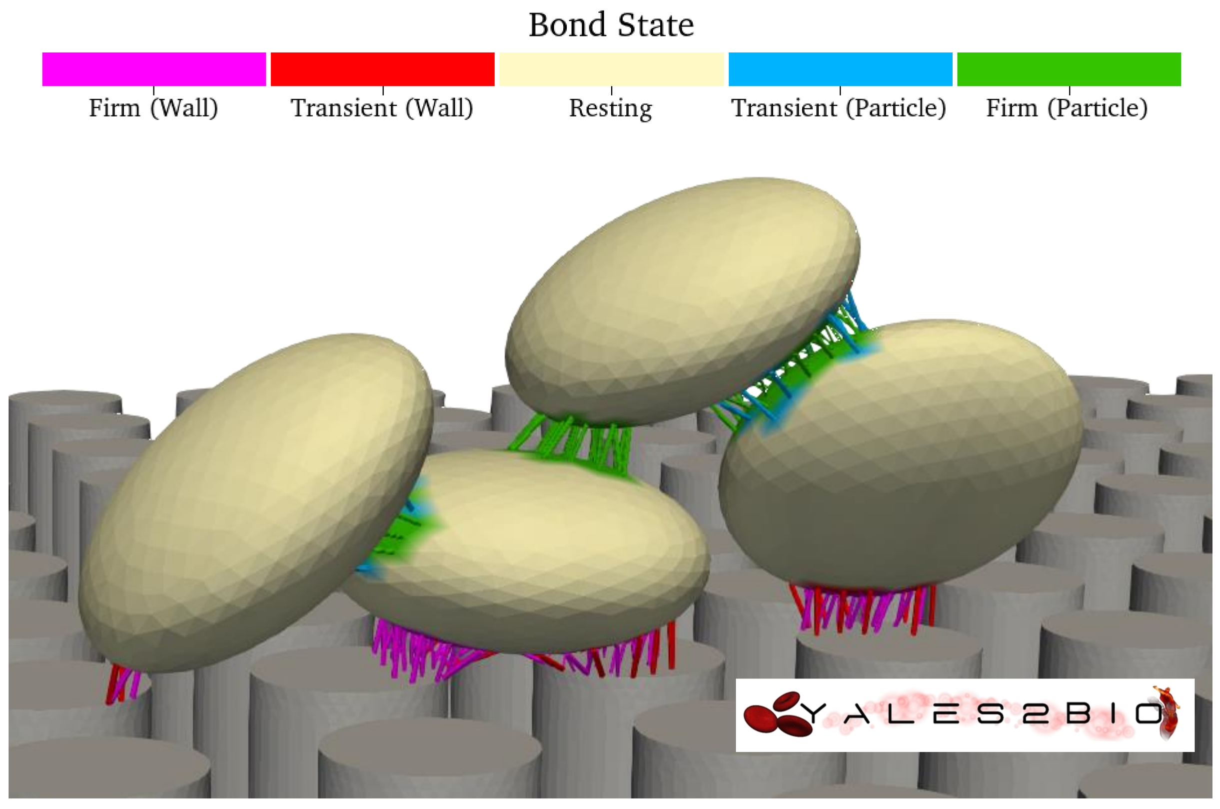
Artificial surface structuring as a bio-inspired technique has shown interesting results in **reducing platelets adhesion**, the initial event in thrombus formation.



Y. Ding et al., J Biomed Mater Res, 2013.

Numerical model

A numerical model has been developed to understand the interaction between the platelet adhesion and dynamics and the structured surface.



Methods

The numerical model is implemented in the YALES2BIO solver developed at IMAG and dedicated to the simulation of blood flows [1]. The surrounding fluid is described by the incompressible Navier-Stokes continuity (1) and momentum equations (2).

$$\nabla \cdot u = 0 \qquad (1)$$

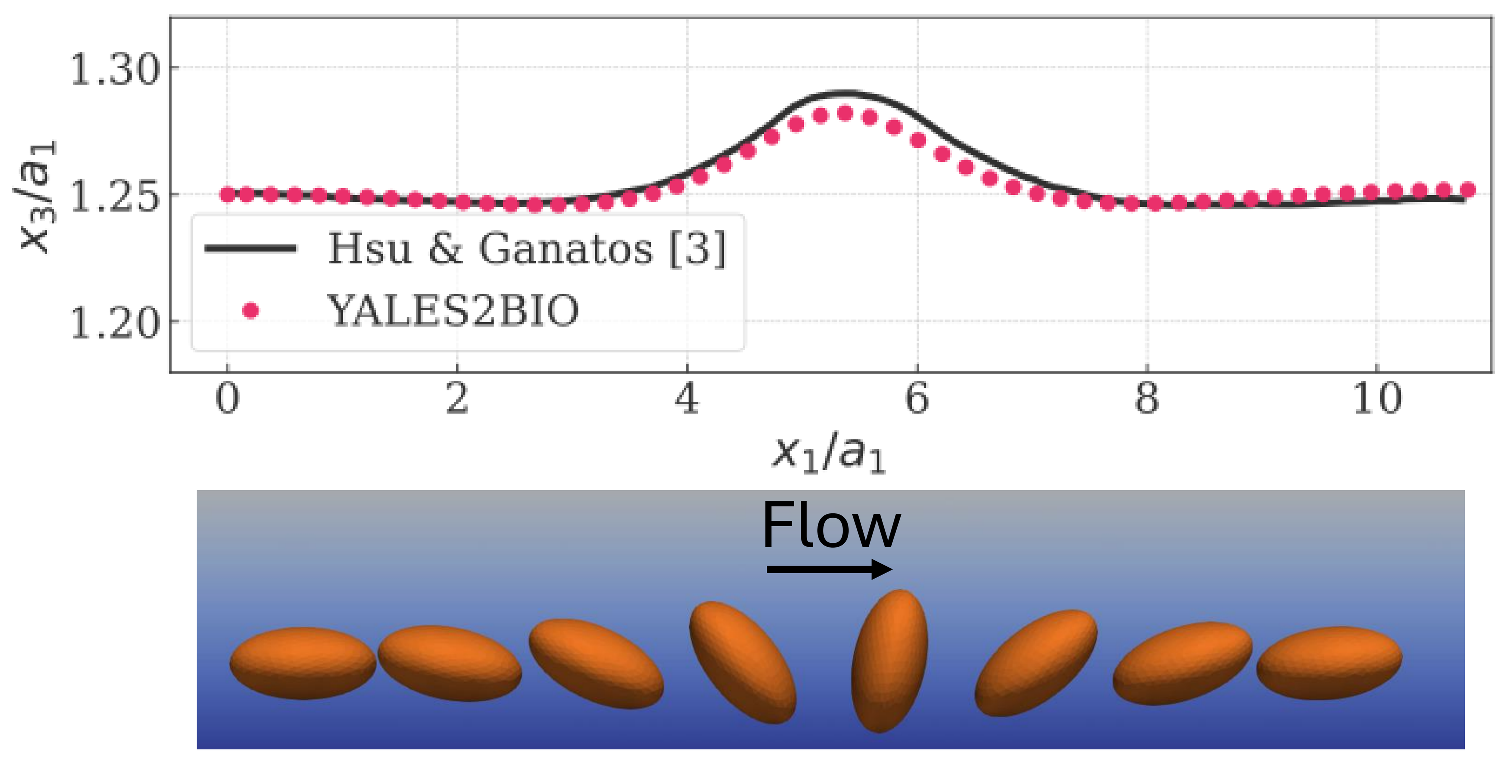
$$\rho \frac{Du}{Dt} = -\nabla p + \mu \nabla^2 u + f(x,t) \qquad (2)$$

$$f_i(x,t) = F_i \Delta\big(x - Y(t)\big) + G_{ij} \frac{\partial}{\partial x_j} \Delta_d\big(x - Y(t)\big) \qquad (3)$$

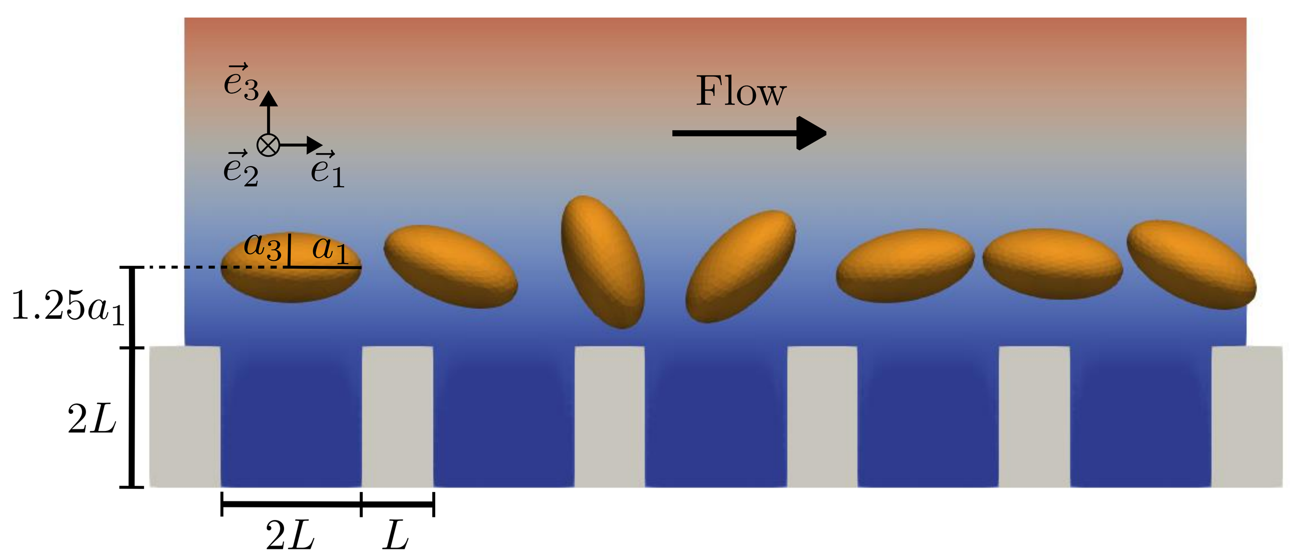
The force density f(x,t) detailed in (3) accounts for the presence of the particle in the flow as prescribed by the **Force Coupling Method** [2] by spreading the external force and torque over Gaussian supports Δ and Δ_d. The linear and angular velocity of the particle are measured by averaging the fluid velocity and vorticity over the Gaussian supports.

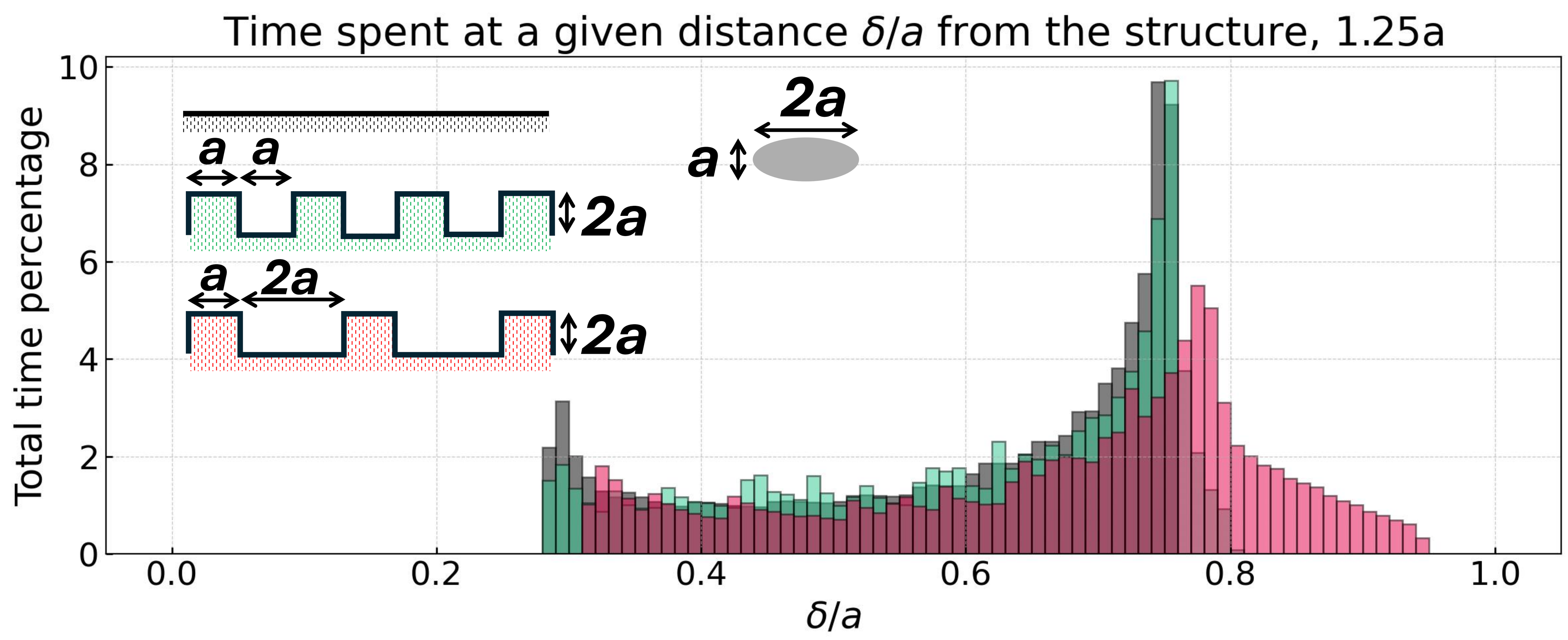
Validation

Flipping motion of a particle with aspect ratio 0.5 near a flat wall in shear flow comparing to results from Hsu and Ganatos [3].



Results : Single particle dynamics over grooved surfaces





Increasing the size of the grooves shifts the mean particle-structure distance to higher values. This might influence the platelets adhesion potential.

[1] Mendez et al, Biological Flow in Large Vessels, 183-206, 2022.
[2] Liu et al, Journal of Computational Physics, 228:3559-3581, 2009.
[3] Hsu & Ganatos, Journal of Fluid Mechanics, 268:267-292, 1997.