The University of Edinburgh - Friedrich Schiller University

Population Dynamics Virtual Seminar

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Pseudomonas aeruginosa respond to surface stiffness via signaling and growth during early biofilm formation

The attachment of bacteria onto a surface, consequent signaling, and the accumulation and growth of the surface-bound bacterial population are key initial steps in the formation of pathogenic biofilms – yet whether, and how, this is impacted by the mechanics of the surface is not known. We use ultrathin and thick hydrogels to create stiff and soft composite materials, respectively, with the same surface chemistry. Using quantitative microscopy, we find that the accumulation, motility, growth and cyclic-di-GMP signaling of the opportunistic human pathogen *Pseudomonas aeruginosa* respond to surface stiffness. Using finite-element modeling combined with experiments, we find that adhesion to stiffer surfaces results in greater changes in mechanical tension in the bacterial envelope than does adhesion to softer surfaces with identical surface chemistry. The cell-surface-exposed protein PilY1 acts as a mechanosensor, resulting in higher cyclic-di-GMP signaling, lower motility, and greater accumulation on stiffer surfaces. Subsequently, PilY1 makes the biofilm lag phase longer for bacteria attached to stiffer surfaces. In the exponential phase that follows the biofilm lag phase, populations of bacteria with functional pilus retraction motors PilT grow faster on softer surfaces. This demonstrates a two-stage mechanoresponse in early biofilm formation.

Bacteria colonize many types of biological and medical surfaces with a large range of stiffnesses. Colonization leads to the formation of biofilms, which cause costly and life-impairing chronic infections. However, whether and how bacteria can sense and respond to the mechanical cue provided by surface stiffness has remained unknown. We find that bacteria do indeed respond to surface stiffness in a way that is both consistent with expectations based on equilibrium continuum mechanics and that quantitatively impacts multiple aspects of early biofilm formation. This is a new understanding for the nascent field of bacterial mechanobiology. Furthermore, this finding suggests the possibility of a new category of approaches to hindering biofilm development by tuning the mechanical properties of biomedical surfaces.

Suggested Readings:

https://www.pnas.org/content/114/23/5906/tab-article-info
https://royalsocietypublishing.org/doi/full/10.1098/rsos.201453
https://www.pnas.org/content/111/47/16860.abstract

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