

RESEARCH TOPIC PRIME8
Microfluidic evaluation of functionalized prosthetic surfaces in the context of periprosthetic joint infections

Thematic field of the project

Biomaterials and biomedical engineering for infection research

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Other facility

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Main field of interest

Biomaterials and bioengineering

Abstract

Periprosthetic joint infections (PJIs), particularly those associated with Staphylococcus species, remain a significant clinical challenge due to biofilm formation and increasing antibiotic resistance. Improved understanding of the interactions between bacteria, biomaterials, and host immune responses is essential to advance prevention and treatment strategies. This PhD project will focus on the development of advanced in vitro and microfluidic (lab-on-chip) platforms to investigate key aspects of PJIs under controlled conditions. Using clinically relevant prosthetic materials, including metallic substrates and industrially provided surfaces, the research will explore bacterial colonization, biofilm development, and interactions with immune cells. Particular attention will be given to surface modification and bio-functionalization strategies, aimed at modulating bacterial adhesion and host responses through chemical and morphological tailoring of implant surfaces. The experimental approach will incorporate different bacterial strains and immune cell models to better reproduce the complexity of infected joint environments. Microfluidic systems will enable precise control of environmental conditions and support detailed analysis of biological processes relevant to infection. These platforms will also be used to assess the response of bacteria to antimicrobial treatments in the context of surface-associated growth. From a

clinical perspective, the project aims to contribute to a better understanding of infection mechanisms and to support the development of improved materials and strategies for the prevention and management of PJIs.

Main technical approaches

The project will employ a multidisciplinary experimental approach combining biomaterials science, microbiology, and bioengineering. Core activities will include the fabrication and functionalization of prosthetic surfaces, using chemical and morphological modification techniques (e.g., sol-gel coatings and surface treatments), followed by physicochemical characterization (e.g., microscopy and surface analysis). Microbiological techniques will be used to culture and manipulate bacterial strains relevant to PJIs, including biofilm formation assays and antibiotic susceptibility testing under surface-associated conditions. In parallel, cell culture methodologies will be applied to maintain and study immune cell models, enabling investigation of host-pathogen interactions in controlled environments. A key component of the project involves the use of microfluidic (lab-on-chip) systems to recreate physiologically relevant conditions. This includes the design, operation, and analysis of microfluidic devices for studying dynamic interactions between bacteria, biomaterials, and immune cells. Data acquisition and analysis will involve quantitative image analysis and standard statistical methods.

The project requires or will provide training in:

- Wet lab techniques in microbiology and cell culture
- Surface functionalization
- Microfluidic experimental design
- Microscopy and surface characterization methods
- Data analysis and interpretation in an interdisciplinary context

Scientific references

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3. D'Agostino A., Bertolini M., Bono N., Pavarini M., Tarsini P., Candiani G., De Nardo L., Chiesa R. Antibacterial titanium dioxide coatings for CoCrMo orthopaedic implants (2023), *Applied Surface Science*, 609, art. no. 155300.

4. Belgiovine C., Pellegrino L., Bulgarelli A., Lauta F.C., Di Claudio A., Ciceri R., Cancellara A., Calcaterra F., Mavilio D., Grappiolo G., Chiappetta K., Loppini M., Rusconi R. Interaction of Bacteria, Immune Cells, and Surface Topography in Periprosthetic Joint Infections (2023), International Journal of Molecular Sciences, 24 (10), art. no. 9028.
5. Pavarini M., Moscatelli M., Candiani G., Tarsini P., Cochis A., Rimondini L., Najmi Z., Rocchetti V., De Giglio E., Cometa S., De Nardo L., Chiesa R. Influence of frequency and duty cycle on the properties of antibacterial borate-based PEO coatings on titanium for bone-contact applications (2021), Applied Surface Science, 567, art. no. 150811.

Type of contract

PhD scholarship of € 21.000 gross per year awarded by Humanitas University. This sum is exempt from IRPEF income tax according to the provisions of art. 4 of Law no. 476 of 13th August 1984 and is subject to social security contributions according to the provisions of art. 2, section 26 and subsequent sections, of Law no. 335 of 8th August 1995 and subsequent modifications.

Borsa di dottorato pari a € 21.000 annui lordi erogata da Humanitas University. Importo non soggetto a tassazione IRPEF a norma dell'art. 4 della L. 13 agosto 1984 n. 476 e soggetto, in materia previdenziale, alle norme di cui all'art. 2, commi 26 e segg., della L. 8 agosto 1995, n. 335 e successive modificazioni.